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DISCOVERY

CAMBRIDGE: JULY 1939

● THE CYCLOTRON: Switching on 9 million volts

● WHAT MAKES YOU A MAN. By Dr C. H. Waddington

(*For full contents see page* iii)

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A New Attempt to Explain Modern Physics

THERE is a real desire among all kinds of people to understand where science is going.

Unless that were true, *Discovery* would not exist. And the letters that come to the *Discovery* office every day give us a first-hand impression of how widespread this curiosity is. It is the most general and vivid intellectual curiosity in the world to-day.

But it still is not being satisfied. No one has yet really learned how to reach all the people who want to know about science. H. G. Wells made an attempt full of genius, but restricted himself to biology (and much of biology has developed since his last piece of scientific exposition: there is now a crying need for simple accounts of genetics, embryology, and the new biochemistry). Eddington and Jeans, in quite different fashions, went home to those who were stirred by the mystical appeal of astronomy and modern physics. Haldane, on the other hand, kept to the crashing materialist appeal—and, like Wells, has not gone beyond biology. Recently, Hogben, in *Science for the Citizen,* has produced a more encyclopaedic feat of scientific explanation than any of the others; his is the only book in modern times even to try to present the ordinary inquisitive intelligent man with the whole of modern science.

Hogben's is an astonishing achievement. It is bound to be criticized in detail by scientists, just as Wells' *Outline of History* was criticized by historians. But scientists are at last realizing that from every point of view their work must be made available and understandable to anyone who wants to attend. And so they have learned a great deal from Hogben's work: where has it failed? How far could it succeed?

The answer seems to be that, so far as it has failed, it fails through one avoidable reason and one unavoidable. The avoidable reason is that too many personal flaws impair the book. They may appear trifling, but their effect is cumulative. This work was conceived as the expression of scientific humanism: it needed ambition and passion to carry it through: those it obtained, but it needed more magnanimity.

But that could be set right. The unavoidable reason why the book will not bring off its ambitious purpose is that no single book could. There are too many major difficulties in explaining science as it must be explained. They will have to be nosed round, they cannot be swept aside at a blow: to bring science, in its richness and variety, before the world to-day needs the co-operation of many men with the most widely different gifts.

The difficulty, of course, is inherent in the subject. We are trying to explain the success of science. And the success of science is due to the fact that it is the most highly abstract, the most highly conceptual and specialized activity that the mind of man can perform. Some of its conceptions are very easy and are used by every one every day of the week; the conceptions in much of biology and chemistry are no more difficult than those we use in managing a garden or cooking a meal or, at the most, solving a crossword puzzle. The conceptions of parts of physics are as easy and of others very considerably harder. They can all be communicated; but they need people with quite different kinds of mind to set about the job, and quite different techniques to do it with. For example, Professor Gamow, completely at ease in explaining the ideas of quantum physics, would probably not be so convincing on the simpler task of describing how to make a coal-tar dye.

This degree of specialization is part of the nature of science. Science itself, in some ways, plays a similar part in the modern world to art in the Renaissance; but the resemblance must not blind us to the immensely greater difficulty of getting it widely understood. The citizens of Florence in 1505 could stroll about a single room and see for themselves Leonardo's cartoon on one wall and Michelangelo's on the opposite one, and judge for themselves how the quarrel was going. But it would not be so much use the citizens of Oxford and Cambridge taking a friendly interest in the controversy between Eddington and Milne about the internal constitution of the stars.

The variety within science, then, is one fact which makes us invent so many techniques for explaining its various parts. The other fact is the prodigiously different interests and equipment of the people who want to be informed. There are a good many who need just the *flavour* of science, who like to feel that they have a nodding acquaintance with what is going on. There is an infinite number of gradations of curiosity and training: down to those who have had some scientific education and who want a more or less expert grasp of the real stuff.

To these—and there is a considerable number, as was proved by the sale of Einstein and Infeld's book on *The Evolution of Physics*—a new series just begun

by the publishing house of Blackie can be enthusiastically recommended. They are quite short books, issued at 3*s*. 6*d*., and the first three are written by two young scientists. Mr A. G. Ward on *The Nature of Crystals* has written a beautifully clear account of a topic both important in itself, intellectually satisfying and strangely unknown to the scientifically interested public. Mr G. K. T. Conn on *The Nature of the Atom* and *The Wave Nature of the Electron* (they should be read consecutively) has treated a more familiar subject with great skill. This series is a really valuable addition to the most difficult side of scientific exposition, and it should interest many readers of *Discovery*.

THE EDITOR

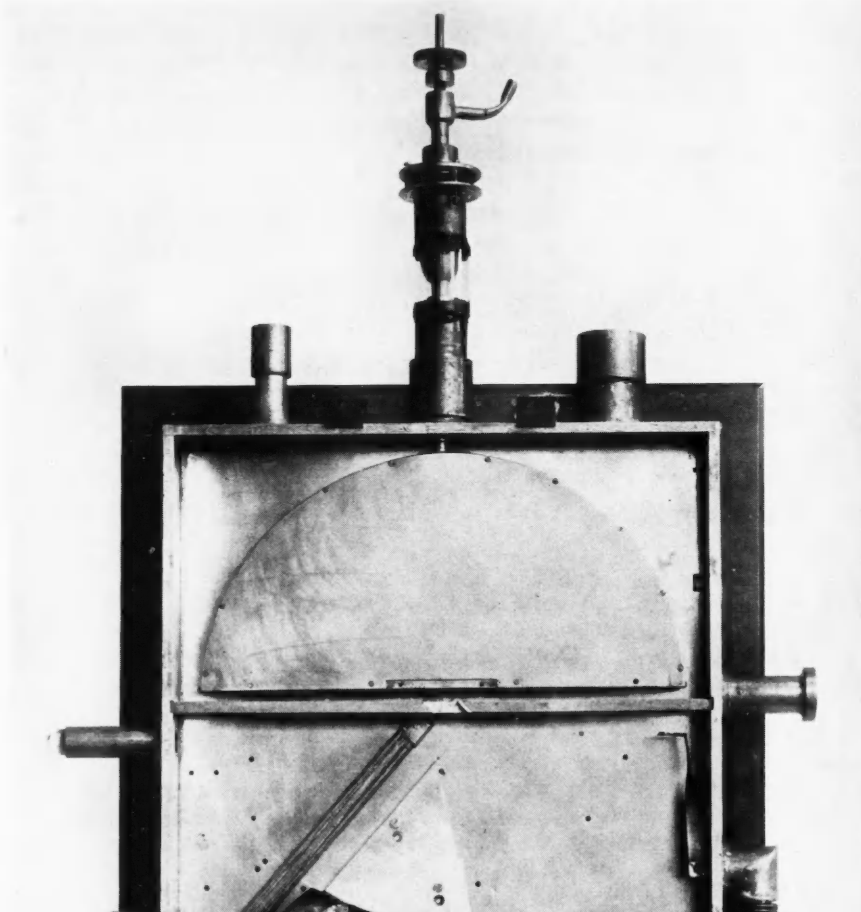
The Cyclotron

By A. K. Solomon

(The cyclotron is the most important piece of apparatus in modern nuclear physics. A note about it appeared in our December 1938 *issue* (Discovery, *vol.* I, *no.* 9). *We have now been able to obtain a full account from Dr Solomon, one of the group of workers now constructing a cyclotron at the Cavendish Laboratory, Cambridge.)*

EVER since the Middle Ages man has been fascinated by the idea of transmutation of the elements. The alchemist's legend was based on the philosopher's stone, that magic mineral endowed with properties which turned the base metals into gold. Many men devoted their lives to a futile search for such a stone. Finally, in 1919, Rutherford carried out the first transmutation. Even now gold cannot be formed from lead. True, gold can be made from other elements, but the amount produced is so small and the cost so high that it is infinitely easier to mine for gold. Yet with the use of modern equipment scientists can bring about many transmutations at will. The philosopher's stone of old has become the atom-smasher of to-day.

The atom itself is a very tiny particle, highly armed by nature to resist attacks on its integrity. Although the forces involved are electrical, it can be imagined as being similar to a walnut, with its distinctive kernel protected by a shell-like wall. To crack a walnut, one's first impulse is to use a nutcracker—and so one would think that a modern great trip-hammer might be used to smash the atom. But that is not the case, for the atom is so small that it would get lost in the surface of the hammer. It would be possible, too, to crack a walnut by standing a few yards away and taking pot shots with a rifle. For a walnut, this would be preposterous, but for an atom, this is the proper procedure. Real bullets are of no use, since the atom could get lost on the surface of the bullet just as easily as it could on the surface of the trip-hammer. To the atom the bullet surface appears porous, like a wire-mesh sieve. The best projectile would be about the same size as the atom, preferably another atom. In practice only the lightest and smallest atoms are used as projectiles because they are easier to handle—just as it is easier to build a rifle than an eight inch gun. Even with atomic projectiles it is difficult to transmute elements. For one thing the projectiles



(*Science Museum, South Kensington. Reproduced by permission of Professor Lawrence*)

Lawrence's 12 *in. Cyclotron*

must have a velocity greater than a million miles an hour. And since metallic surfaces appear porous, one must continue shooting until by chance one makes a collision. Imagine the walnut lost in a haystack. It could be hit by firing a machine gun at the haystack, but it would take a long time.

It can be seen that there are stringent requirements for a modern atom-smasher, or rather atomic machine gun, since that is a more accurate term. The first necessity is a source of projectiles which must be inexhaustible, since only about one particle in a million effects a transmutation. Then the beam of projectiles must be collimated, i.e. the gun must be aimed at its target. And finally, there is the power source, i.e. a method must be devised to enable the projectiles to attain their terrific velocities.

In 1929 in California, Ernest Lawrence began experiments in an attempt to devise a method for the acceleration of particles. Rather than attempt to build a generator which would deliver the necessary voltage in one big dose, Lawrence and his collaborators used a low voltage which they applied often. With a source of particles at one end of a long cylindrical glass tube, they accelerated the particles along the tube, using cylindrical attractive electrodes spaced out inside the tube. With ten electrodes and 20,000 volts on each, a singly charged particle will have, after going through all the electrodes, energy of 200,000 volts. The problem was to keep the voltage always in step with the particles, so that as they reached each separate electrode, the volts were there as well to pull the particles along. Lawrence solved this with a wireless generator, and finally, in 1931, he announced the production of 1,250,000 volt particles.

But the difficulty with this method is the length of the tube. The possibilities of wireless set a limit to the voltage on each electrode—and once this limit is reached higher energy can be secured only by making the tube longer and longer. And then, as the energy of the particles increases, they are more difficult to handle and the internal structure of the tube must become more complex. Rumour has it that Lawrence's unique solution of this problem was suggested by an obscure paper on the action of these particles in magnetic fields.

The solution is as simple as it is ingenious. The particles must travel around in a circle so that they pass between the same electrodes a great number of times, gaining voltage each time. In a strong magnetic field charged particles travel in circular orbits. The apparatus containing one or two electrodes is placed between the poles of a magnet, and at one stroke all the cumbersome glass tubing becomes unnecessary. The trajectory of the particles is shown in the spiral line in the figure on p. 334. As the particle gains voltage it goes faster, and the faster it goes the more difficult it is for the magnet to force its path into a circle. As a result the particle describes circles of larger and larger radius. A peculiar and important law applying to particles in a uniform magnetic field is the one which states that, regardless of velocity, like particles will describe a semicircle in exactly the same time. Thus it takes as long for the projectiles to get from *A* to *B* as from *B* to *C*, or *C* to *D* and so on. Although they have increasingly large distances to travel, the particles are going increasingly fast, and the increase in speed exactly makes up for the increase in path.

The first cyclotron, only 6 in. across, could easily be placed between the poles of a small magnet. The results were so encouraging that Lawrence proceeded to build his 12 in. cyclotron, reproduced here, on p. 332, and now on exhibition in the Science Museum. The first necessity for an even larger cyclotron was a magnet, and Lawrence was especially fortunate in the gift of an 85 ton magnet, which was large enough to take a 3 ft. cyclotron tank between the poles. With this machine, now in operation, deuterons with energies of about 8,000,000 volts are produced. Yet the demands of modern science far exceed the supply, so the cyclotron is run continuously 24 hr. a day. But still unsatisfied,

The Cavendish Cyclotron with top plate removed

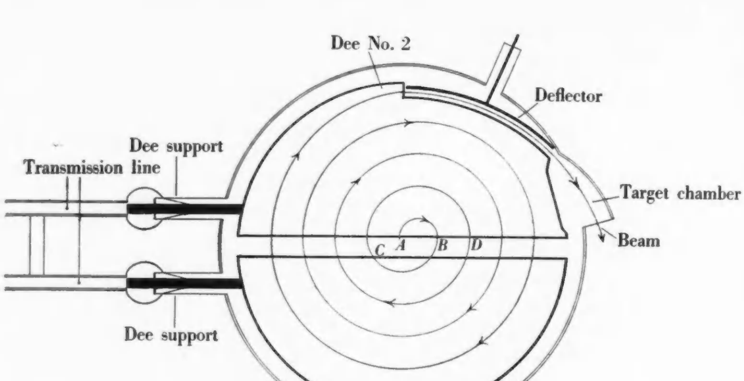


Diagram showing the path of particles inside the Cyclotron

Lawrence has already almost completed work on a 5 ft. cyclotron. The two pictures on p. 338 give some indication of the size of this tremendous machine with its 220 ton magnet. The emergent deuterons should have an energy of 20,000,000 volts, far higher than ever artificially attained before.

Here at Cambridge we have constructed a 3 ft. cyclotron, and the 9,000,000 volt deuterons we have produced represent now, until the completion of Lawrence's new machine, one of the highest voltages so far artificially achieved. The diagram on the opposite page gives a clue to the inside of the Cambridge cyclotron. The main constituents are the two electrodes, called dees, because in shape they represent the letter "D". These are hollow semi-cylindrical copper electrodes. One can imagine two saucers clapped together face to face, tightly fastened at the joint, then cut in half at the diameter. If they were made of copper and 3 ft. or so across these would function very well as dees. The particles travel inside the dees, gaining energy as they move in ever-widening spirals.

Between the dees at the centre of the tank is the filament which serves as ion supply. So far we have called the projectiles either atoms or particles, and the first of these terms is inaccurate, while the second is not descriptive. It is obvious that any simile which considers the atom a walnut must over-simplify. The worst mistake in such a naïve picture is that one has taken no account of the electrons which are continually whirling in fixed orbits about the atoms. That there are electrons does not invalidate the walnut picture; it merely adds a complication. Thus, that there are planets whirling about the sun does not make the sun any different; it is merely that the solar system is more complex than the sun alone. In the atom there is the charged nucleus, which we have hitherto called the walnut, and this nucleus is surrounded by a cloud of electrons. The nucleus, with or without its electrons, remains the same nucleus—and transmutation is attained only when the nucleus itself is hit. Similarly, the particles used as projectiles in bombarding are nuclei, not complete atomic systems. The three most important such particles are protons, deuterons, and alpha-particles. Singly charged protons are made by stripping the electron from the hydrogen atomic system. Deuterons, also singly charged, are made in the same way from heavy hydrogen, and owe their name to being twice as heavy as ordinary protons. Finally, alpha-particles, with a double charge, are helium nuclei without any extranuclear electrons.

One method that can be used to remove the electrons from an atomic system is to bombard the system with other electrons. In practice in a cyclotron this is easily attained. The hot filament between the dees emits electrons and can be arranged to supply them with enough voltage so that they are able to remove the extranuclear electrons in hydrogen or helium. The action of the magnet serves to keep the emitted electrons in the very centre of the tank, so, if a small amount of the necessary gas is kept in the tank, there is an almost illimitable supply of bombarding particles.

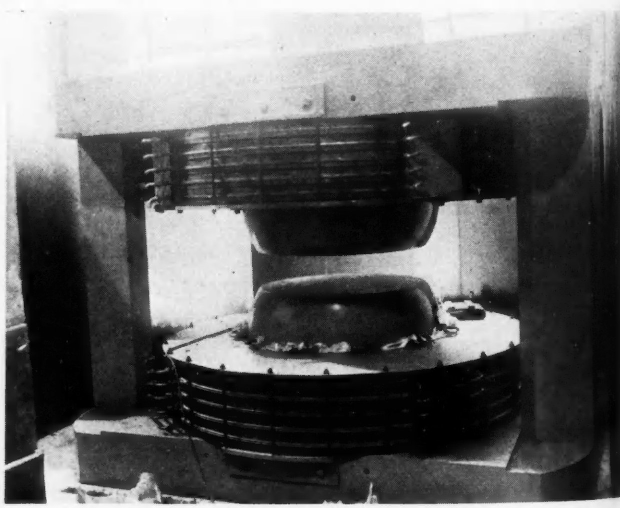
* * *

The problem of pressure inside the cyclotron is an interesting one. For the deuterons to spin round satisfactorily, one has to have a highly efficient vacuum, or else the deuterons would collide with other nuclei before they emerged from the system. Such a collision would deflect the deuteron and it would wander about haphazardly inside the tank until it hit a wall or lost its energy in some other way. It is a simple matter to keep the air out of a small 12 in. tank, but to keep an entire 3 ft. tank completely free from air is no easy task. Of course, the usual precautions are taken by sealing all the joints, but even the best regulated apparatus occasionally springs a leak. The accredited technique for filling these leaks is to plaster them with plasticine.

To be effective the cyclotron beam must be focused. Otherwise the particles would spread out vertically, hit the top or bottom

The Cavendish Cyclotron, October 1937

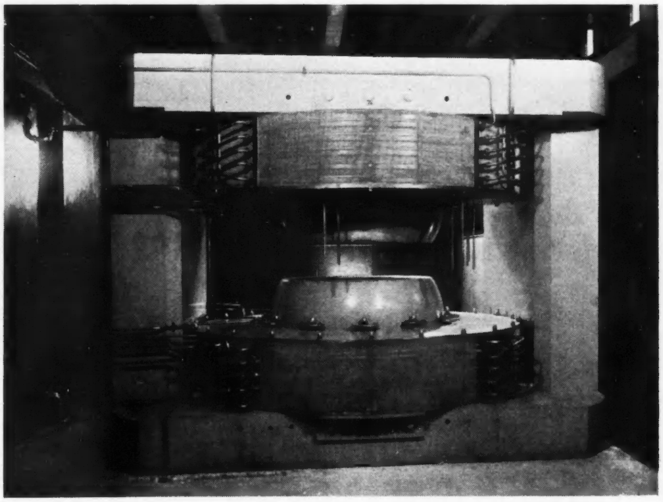
of the dee and lose all their energy. Likewise, when it emerges, the beam must be able to be directed at a small target, rather than scattered at random over a large area. The shotgun is not very useful in scoring bull's-eyes. As in an electron microscope the focusing is done both electrically and magnetically. In the centre of the tank the voltage on the dees exercises a focusing effect, while towards the periphery, where this effect is diminished, the magnetic field focuses the particles towards the median plane of the dees. Matching these two effects so that the final beam is neither too wide nor too narrow is a difficult task. "Shims", iron sheets inserted between the magnet poles and the cyclotron tank, are used to make the adjustments in this matching. The position



A further stage in construction, December 1937

of these shims is highly critical, and makes a great difference in the number of particles which finally arrive at the target. These have travelled almost 60 yards since they left the centre of the tank.

Finally, the particles have to be removed from the tank so that they may be directed against some suitable target of the material to be bombarded. In Lawrence's early cyclotron the projectiles were collected inside the tank. Even so it is necessary to deflect them slightly from their ordinary circular path. The particles emerge from a window in one of the dees, and are pulled out of their normal orbit by putting an attractive voltage of from 60,000 to 100,000 volts of direct current on the deflector plate, shown in the diagram. In the Cavendish cyclotron, as in a great many others, the target is outside the tank, with resultant



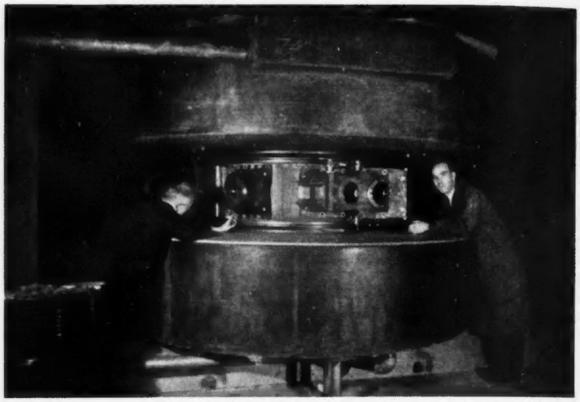
The Cavendish Cyclotron nearing completion, February 1938

advantages of ease in manipulation and changing of targets. But like other cyclotron advantages this is balanced by equal and opposite disadvantages, for with the target so far from the normal orbit it is difficult to obtain a sufficiently high attractive potential on the deflector to bring the particles out.

The attractive voltage on the dees, mentioned so glibly, is brought down a transmission line along a lead inside the insulating dee supports to the dee proper. The problem demands an alternating current. That is, a particle at *A* must be attracted into dee number 2 then, when the same particle gets to *B*, it must be attracted into dee number 1. So while the particle is travelling from *A* to *B* the attractive volts must move from dee number 2 to dee number 1. Then as the particle goes farther from *B* to *C* the volts must move back again to dee number 2, and so on. With a given magnetic field, and a given particle—a field of 17,000 oersteds, and deuterons in the Cavendish cyclotron—the requirement is that the voltage makes a complete change from dee to dee 12,000,000 times a second. The only method known for producing this rapid change is by the use of modern wireless technique. Twelve million times a second is a frequency of 12 megacycles, or else a wave-length of 25 metres—a wave-length which is used in amateur broadcasting.

The Cavendish Cyclotron in use, June 1938

Consequently the cyclotron builder is forced to construct a transmitter, but the power requirements are such as to stagger an ordinary amateur. The Cavendish cyclotron is powered by somewhat more than 100 kilowatts. In comparison, the short-wave trans-

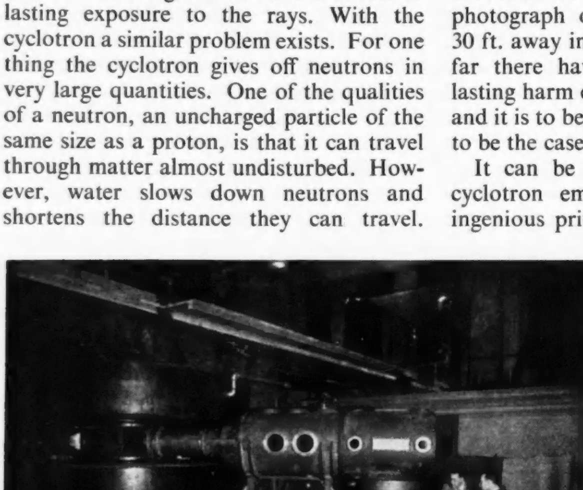


The 60 *in. Berkeley Cyclotron*

mitters at Daventry operating on about the same wave-length are rated at from 10 to 50 kilowatts. In Daventry the effort is to broadcast the power; in the cyclotron the trouble is to keep it in and make it all, or a large portion of it, appear on the dees. The Cavendish cyclotron has been built in the midst of a group of other laboratories; the loud and voluble complaints of other scientists have impelled every possible effort to keep the wireless waves from getting out of the room and disturbing their instruments.

In the early days of work with X-rays and radium, many workers were very badly burned due to ignorance of the effects of lasting exposure to the rays. With the cyclotron a similar problem exists. For one thing the cyclotron gives off neutrons in very large quantities. One of the qualities of a neutron, an uncharged particle of the same size as a proton, is that it can travel through matter almost undisturbed. However, water slows down neutrons and shortens the distance they can travel. Consequently the cyclotron is completely surrounded by water tanks 3 ft. thick—a veritable wall of water. And if this should not suffice, the control table, from which the machine is operated, shown in the photograph on p. 339, can be removed 30 ft. away into a neighbouring room. So far there have been no reports of any lasting harm coming to cyclotron workers; and it is to be hoped that this will continue to be the case.

It can be gathered that although the cyclotron embodies a very simple and ingenious principle, it is not easy to construct. At Cambridge the first plans were drawn up in October 1936, and actual work on construction in the laboratory began a year later. Since October 1937, three and occasionally more scientists have been constantly at work. Yet only now have we achieved a beam of 14 microamperes of 9,000,000 volt deuterons. This figure seems ridiculously low when one considers that it embodies only 126 watts. And to produce these 126 watts, about 120,000 watts are required

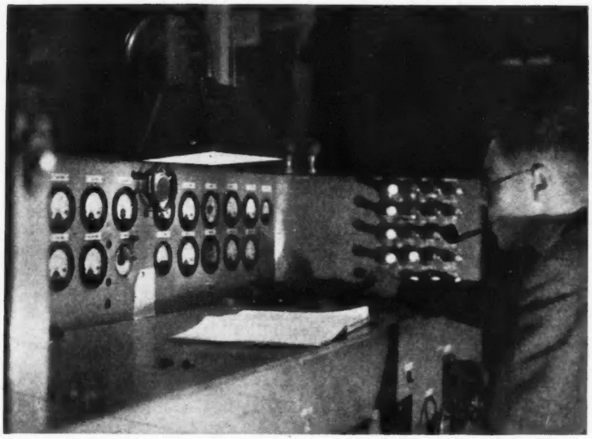


Another view of the Berkeley Cyclotron

to power the magnet and the wireless station. It is hardly efficient, yet it remains the only feasible method to date of artificially producing 9,000,000 volt particles.

Discussion of the cyclotron brings up the inevitable question of "Why smash the atom?" There are two answers to this. First, the scientist wants to find out just what is inside the nucleus and what makes it tick. As with a watch the simplest way is to take it apart. And we, like most amateur watchmakers, still have parts which we cannot put back. The methods for observing what happens to the split atom, and the results when one finally does know, would require still another long article. Secondly, and here perhaps the cyclotron is especially important, it is of great use in the production of artificial radioactivity. The investigation of the biological significance of this radioactivity is only beginning, and one cannot foresee the consequences and ultimate value of such research. The neutrons which are so disturbing to cyclotron workers are also of biological importance as penetrating radiations, and much effort is being spent in discovering the therapeutic and lethal value of such radiation.

The operation of the cyclotron has been described far more concisely. One day a very old lady came to see the machine. She took one horrified look at the room, with its complexity of apparatus and diagram. Then before I could say a word, "Thank you very much, young man. I see what you do. You lead the atom around until it is so dizzy it breaks up in despair." And so we do.



The control table from which the Cavendish Cyclotron is operated

* * *

The fundamental equations that govern the operation of the cyclotron are

$$\lambda = \frac{2\pi mc^2}{He},$$

where λ is the wireless wave-length, m is the mass of the particle, c is the velocity of light, H is the magnetic field in oersteds, and e is the charge on the electron; and

$$V = 150\,\frac{H^2r^2}{c^2}\,\frac{eZ^2}{m},$$

where V is the final voltage of the particle in electron-volts, r is the radius of the final path, and Z is the unit number of charges the particle carries.

A good reference for a paper on the cyclotron is Lawrence and Livingston, *Physical Review*, XL, 19 (1932); a semi-popular discussion of the Cavendish cyclotron will be found in Cockcroft, *Journal of Scientific Instruments*, XVI, 37 (1939).

An Earwig Problem

Why do the Forceps of Earwigs Vary?

By Malcolm Burr, D.Sc., F.R.Ent.S.

A GLANCE at any collection of earwigs will show that in the common species, *Forficula auricularia* L., the only kind that anyone but specialists is likely to meet, the forceps are different in the sexes. Those of the female are simple, straight and tapering. Those of the male consist of two distinct portions. The basal part is broad, nearly parallel-sided, with the inner edges serrate. This part ends in a strongly marked spike or tooth, which is a specific character. Beyond this tooth the branches are abruptly narrowed and gently arched, till the tips meet, thus enclosing an oval area.

In literature it has been repeatedly stated by most authors, including myself, that a dimorphism in the male forceps runs through the order, and that in most species there are two types of male forceps, a short and a long, termed respectively the brachy- and macrolabious forms. It is to be noted that in some exotic species there is a vertical spine or tooth on the upper surface of the forceps, and that in macrolabious specimens this spine is caught in the process of stretching, as it were, and drawn out into a crest.

As the common earwig is so abundant in Europe and the forceps at once so variable and easy to measure, like the jaws of a stag beetle, it is an admirable subject for the study of variation in secondary sexual characters.

As long ago as 1892 Bateson and Brindley took advantage of this and measured the forceps of 583 adult male earwigs. They found that the shortest pair was 2·5 mm. long, the longest 9 mm. When they plotted the lengths against the numbers, they found them grouped about two peaks, a low peak about 3·5 mm., and a high peak about 7 mm. Intermediate forms were very few. The obvious conclusion was that there is dimorphism in the earwig forceps, a high form and a low form, and that the variation takes the form of a bimodal polygon. So the expression "high" and "low" forms was accepted in the literature of the order.

A Russian named Diakonov came to similar conclusions. He noticed, too, that there are other lines of variation, but he considered that they were such minute differences that they do not permit exact measurement. These conclusions held the field until 1924, when they were challenged by Kuhl. He visualized the problem from a different angle, and set to work to decide whether this apparent dimorphism of the earwig is due to the existence of two distinct biological races, that is, whether the forms are hereditary and intrinsic, or whether extrinsic, due to environmental conditions. He established a whole new and elaborate technique of exact measurement, not confining himself to length only. He came to very interesting and somewhat surprising results.

In criticizing the work of the previous authors, Kuhl points out that their statistics are based on incomplete material. He maintains that for statistical work it is essential to collect by mass, and not by the mere accumulation of individuals. In their method of collection he sees the false premises upon which his predecessors erected their results. No amount of skilful treatment can produce sound conclusions unless the foundations are irreproachable. Bateson and Brindley and Diakonov measured a few hundred males. Kuhl collected 11,630 earwigs, of which he measured 4596 males and 3316 females. The former workers measured on paper

squared to millimetres; Kuhl measured to the tenth of a millimetre. They measured length only; Kuhl measured no less than ten dimensions and ratios. They produced one or two graphs; Kuhl gives several dozen.

The dimensions and ratios which he used are as follows (see fig. 1 below):

L. Length, from insertion to tip.

B. Breadth, at base.

A_1. Length of basal, broad portion, as far as big inner tooth.

A_2. Length of narrow, apical portion, from big tooth to apex.

A_3. Width of space between the tips when these fail to meet, even when the forceps are closed.

R. Radius of curvature of the slender portion.

The ratio L/B, i.e. length to breadth.

The ratio A_2/A_1.

The count of the serrations on the inner face of dilated portion of each branch.

B_1. The breadth of the last dorsal segment at the insertion of the forceps. Owing to the flexible, telescopic nature of the abdomen, this is the only practical constant for the breadth of the abdomen, and as a measure of the size of the individual.

In the simple forceps of the female the only dimensions available are length, breadth and B_1, breadth of the last dorsal segment.

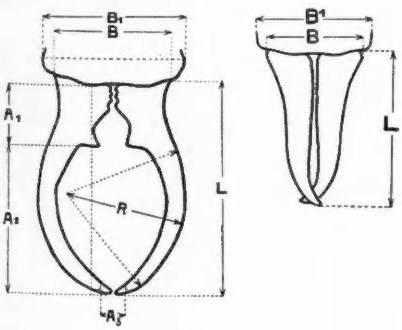


Fig. 1

Of all the earwigs examined he took the shortest and the longest male, and then built up between them a series of sixty gradually increasing in length. To exhibit these at one glance he arranged them progressively in a circle, as shown in Fig. 2.

Fig. 2

He also arranged them longitudinally, as seen in Fig. 3. In his work published in 1928 he reproduces this so greatly enlarged that it covers three entire pages. These figures bring out prominently the fact that there is a gradual progression from the shortest to the longest. There is no question of arranging them in two well-separated groups, a "low" and a "high". There is no more talk of dimorphism, of brachy- and macrolabiism.

Further, the highly magnified figures bring out a whole series of smaller differences, down to the serrations on the inner margin of the basal portion. There are, in fact, as in a pack of hounds, a flock of sheep or a crowd of men, no two alike. Every earwig has its own individuality.

In examining Fig. 3 it will be noticed that in almost all cases the points of the forceps, when completely closed, meet or even cross. There are, however, eight individuals out of the sixty in which the tips do not meet when these organs are

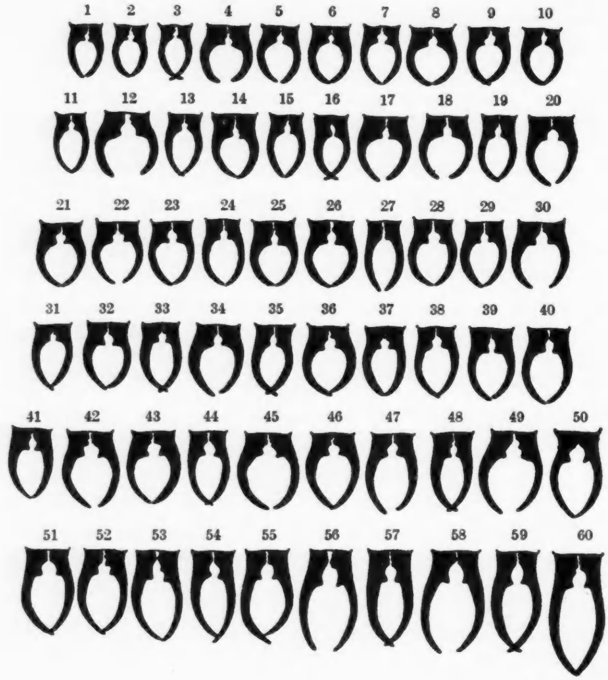


Fig. 3

completely closed. That is to say, the dimension A_3 has a value ranging from 0·2 to 0·8 mm. In the remaining fifty-two, the value of A_3 is zero. This apparently trifling point has a profound significance. Individuals with this feature are nos. 4, 10, 12, 17, 18, 20, 22, 30.

Another distinctive point about these

Fig. 4

eight specimens is that they are all clearly broader than the others of the similar length. That is, the inner tooth is situated farther away from the base. In other words, A_3 has a much higher value than in the other fifty-two. There is after all a division into two groups, not, however, a short and a long, but a *narrow* and a *broad*. Those with a value for A_3 are without exception broad.

This is shown clearly in Fig. 4, where the shortest and the longest are figured, that is, nos. 1 and 60, together with no. 4, a typical broad specimen. They are shown magnified proportionately, but, in addition, nos. 1 and 4 are shown magnified to the same length as no. 60, the longest. This shows that the extremes are the same in outline, differing only in length, while no. 4 is quite different in outline. Between the first two there is a difference of degree, but no. 4 differs also in kind. Such a difference of outline has in the past often been treated as a specific character.

Kuhl next proceeds to the statistical examination of his material, in an elaborate series of graphs, of wooden models, and plotted diagrams. He plots the ten dimensions and ratios against each other and the separate populations of each of the three localities from which he took his material, and also for the different years. He also plots the females and the malformed specimens. Fig. 5 illustrates his method of using wooden models. This highly detailed analysis confirms the point made pictorially, that the forceps fall into two groups based not upon their length, but upon their breadth. The short, broad form stands out sharply from the main group, whether short or long.

With a single exception they all show but one peak. The exception is the population from Holstein, where there is the beginning of a second peak. The cause of this is incomplete collection. From Holstein he had only 560 specimens, whereas from the others he had from 1053 to 1706. The exception is only apparent, but it is instructive, illustrating the fallacy that vitiated the work of earlier authors. All the other graphs and models show vividly that there

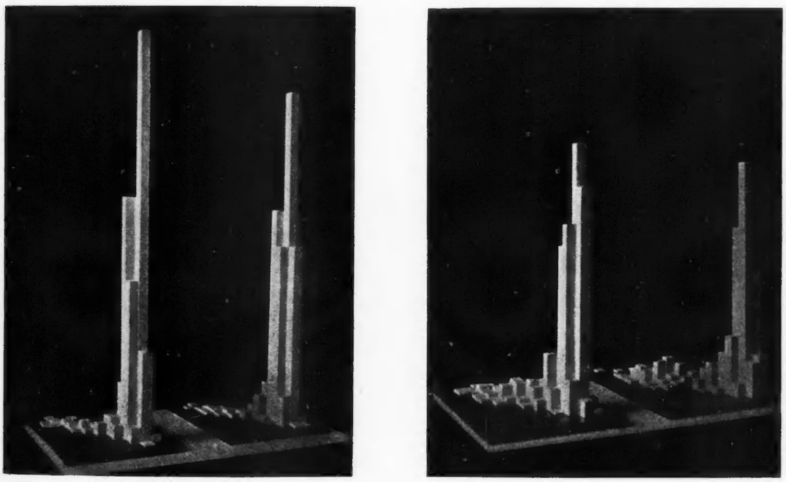


Fig. 5

is but a single, well-marked peak. There is no dimorphism. The variation is unimodal.

Kuhl next considers the significance of malformed forceps. All who have ob-

served earwig collections are familiar with the appearance of such specimens. There are various types of malformations. Sometimes the branches are alike but asymmetrical; in others they are of quite different form; sometimes one branch is missing. Individuals with one branch simple, straight and toothless, like those of a female, are often described, even by experienced entomologists, as gynandromorphs. As long ago as 1910 I pointed out the fallacy in this. All specimens which I have ever seen with any indication of the male type of forceps have the male type of abdomen, that is to say, nine abdominal segments. As in the adult female the seventh and eighth segments are atrophied, and the possession of the full complement of nine is clear indication of the male sex. This is confirmed by the only instance of which I am aware of the dissection of such a specimen.

Diakonov regarded all malformed specimens as instances of regeneration. This is often the case, but not always. One feature of regeneration is the failure to produce the large inner tooth so characteristic of the male. The reason is that the regeneration inflicts such a drain upon the energy of the insect that there is not sufficient left to form the big tooth. Regeneration, the repair of a damaged organ, is the result of external causes. Other forms of malformation are caused by internal, physiological influences acting upon the development during the larval and nymphal instars. This, as Julian Huxley has shrewdly suggested, provides the key to the variability of these organs. When the nymph is about to shed its skin for the last time, the future complex forceps are contained within the simple nymphal sheath, tightly folded longitudinally (Fig. 6). At the moment of ecdysis, when this organ, in so delicate a condition, is withdrawn from the sheath, the slightest unfavourable movement or contact may inflict a wound. But the danger is not over even when the young forceps are completely disengaged. The next stage in the process is their inflation by the pressure of the haemolymph, just as one may by breathing inflate a glove. This imposes so great a strain upon the tissues that the cells are involved in distortion. If the nymph has been well nourished throughout its larval life and the pressure be adequate, this process is carried out satisfactorily. The result of these optimum conditions is a well-formed, big specimen, with forceps complete in every respect. This is the sort known as "var. *forcipata*", the macrolabious, or "high" form. With this type defects never occur.

If the creature has suffered from inadequate nourishment during larval life, the pressure of the haemolymph is also inadequate, and therefore cannot inflate the young forceps completely or rapidly enough. The result is a stunted form. The future health of the adult may be foretold from the size of the larva. Just as with the human species, underfed juveniles make undersized adults.

Fig. 6

The critical moment in the life of the individual, then, occurs during the final ecdysis and the few moments preceding. If at the beginning of the moult the air intake be impeded by the constriction of the head with a silk thread, there is not enough power completely to inflate the forceps. They come out simple, straight and short. If this be done when the moult is half-way through, the forceps are curved, but insufficiently blown out. Once the chitin has hardened, which takes place in about ten minutes, the damage is fixed.

Kuhl brings out the fact that the number of cases of the short, broad form with

gaping tips is for each locality inversely proportional to the number of "high" forms. The highest value of A_3 occurs with the lowest frequency, the lowest value of A_3 with the greatest frequency. The explanation is that the cause of the short, broad form with high value of A_3 is pathological. The short, narrow forms are merely stunted, but the short, broad forms with high A_3 arise from big, well-fed nymphs, destined for the maximum type, but something "went wrong". Probably some external influence brought about inadequate pressure at the critical moment, so that they failed to attain the maximum length. The final appearance of the individual is the product of hereditary factors and post-natal influences, the latter being either physiological, that is, the amount of nutrition absorbed during larval life, or physical, that is chance external contacts or accidents, especially at the time of ecdysis.

Kuhl has shown, therefore, that the high degree of variability in the forceps of the common earwig in both sexes, but particularly in the males, is not a hereditary feature, but due to external causes. The dimorphism is not racial. It is the modificability that is hereditary. It is a striking parallel to the conclusions of the anthropologists, that in the human species hereditary conditions have but little influence upon the individual, that by far the greatest proportion of his characteristic is the result of external cultural influences. Like the human being, the earwig is the victim of circumstance.

Notes of the Month

ANALYSIS BY INFRA-RED SPECTRA

PROGRESS in physical chemistry depends to a very marked extent on the discovery of new methods of analysis. Observations on the infra-red absorption spectra are now being used to study reactions where the changes involved are too small appreciably to affect the commoner physical properties such as vapour pressure, thermal conductivity, etc. Such reactions have become increasingly vital, particularly since the discovery of deuterium and the use of the exchange reactions between hydrides and deuterium, and between hydrides and deuterides to elucidate the mechanism of chemical reactions. Infra-red analysis is becoming of more importance with the development of high dispersion spectrometers and the elucidation in recent years of the general background of molecular spectra.

This method of analysis was used by H. S. Taylor and co-workers in America to follow the exchange reaction between methane and deuterium. These workers used a low dispersion spectrometer and observed the progressive change in position of the absorption bands of the methane as deuterium was substituted for hydrogen. The method has been developed further in a recent paper from the Cambridge laboratories in which the possibility of exchange between light and heavy ethylenes (C_2H_4 and C_2D_4) was investigated. The problem here is to determine the *distribution* of deuterium among the ethylenes. Exchange is characterized by the appearance of "cross-compounds", C_2H_3D, $C_2H_2D_2$ and C_2HD_3, which leaves the total deuterium content, and thus the physical properties of the mixture, unchanged. High dis-

persion infra-red analysis, however, can detect these compounds, as each has its characteristic absorption bands distinct from the others; furthermore, since these bands are distinct and separate, the intensity of absorption can be used to estimate the quantity of each.

Another problem to which infra-red analysis is being applied is that of the "hydrogen bond", e.g. the loose binding of a hydrogen atom of a hydroxyl group to another oxygen atom. When such a bond is formed, the narrow absorption band characteristic of the O—H bond is weakened and a broad band at slightly longer wave-length characteristic of the "hydrogen bond" appears. L. L.

(*Twigg and Conn, Cambridge*)

A NEW TREATMENT FOR SPRAINS

MOST people know the excruciating pain and the extraordinary degree of prolonged incapacity from what is often regarded as "just a sprain". A revolutionary treatment of this condition, which, within almost a few hours, really does enable the cripple to throw away his crutches, was described a short while ago by Leriche, the famous French surgeon. It has recently been tried in England, and an account of its use at a R.A.F. station has just appeared. The principle is to inject into the damaged part a solution of procaine, a local anaesthetic of the cocaine type. This relieves the pain almost at once, so that movements, a moment ago impossible because of the agonizing pain, can now be carried out with no difficulty at all. Frequently, the pain returns somewhat in a few hours, but it lasts only a short while, then passes off for good. It is then usually possible to return to full normal work on the next day. The airmen treated at the R.A.F. station before the introduction of this method were off duty on an average for 10 days. Since procaine injection has been used, this has been reduced to 2 days. J. Y.

(*Moynahan, England*)

NEW SYNTHETIC RESIN FOR BLOOD-SYSTEM MODELS

IN the past, models of various parts of the human anatomy have been made from specimens taken from the morgue by injecting coloured waxes or resins or solutions of cellulose into the veins, arteries and other ducts of the specimen and allowed to solidify. The surrounding tissues are then dissolved away in acid leaving a model of the structure in a relatively stiff and non-putrefying substance.

The troubles in the past have been associated with the low melting-point of the wax which softens and wilts in hot weather while cellulose solutions require a long time for injection, and the specimen has to be immersed in a very weak corroding fluid to prevent attack of the model. This process sometimes took months. A new synthetic resin, polymerized vinyl chloride, which is glass clear, relatively hard and extremely inert, enables the whole process to be carried out speedily, resulting in a model which has none of the defects of waxes. The great chemical stability of vinyl

resins enables them to be used with concentrated (38 %) hydrochloric acid solutions for corrosion which completely dissolves the tissues in 70 hours, but leaves the resin unattacked.

An exact and extremely accurate reproduction of the actual arrangement of the system is thus preserved as a permanent plastic model, which will not distort or crack for future study, demonstration or diagnosis. A further advantage is the mechanical strength of the specimen. It requires no special mounting. The resin before injection is coloured to correspond with the actual tissue, and the solution is sufficiently thin to enter the very finest capillaries.

H. COURTNEY BRYSON

THE PERCEPTION OF PITCH IN INSECTS

IT is well known that certain insects, especially those like grasshoppers that possess stridulating organs, are able not only to hear, but also to distinguish between sounds that differ in pitch or quality. They respond, for example, to the stridulation of their own species but not to that of strangers. In vertebrates this power of pitch perception is dependent on the characteristic structure of the inner ear, which acts as a multiple resonator of which each region is excited by notes of a particular frequency. Since the "ear" of an insect consists of a simple tympanum no such explanation is possible in their case. It might be possible that perception is direct—that is to say that each vibration generates a separate impulse in the nerve, but here there is a difficulty in that whereas the nerve is incapable of conveying more than a few hundred impulses per second, the insect appears to be deaf to notes with as low a frequency as this.

A new theory has been put forward to get round this difficulty. It appears that what insects respond to (as is the case with wireless sets), is not a simple note, but low-frequency modulation of a high-frequency carrier wave. (By modulation is meant regular variation in the intensity of the carrier wave.) Experiments in which activity in the nerve was detected by amplifying the electrical changes that accompany the transmission of impulses showed that a grasshopper is completely deaf to notes up to 300 cycles per second (about the bottom of the treble clef); to a pure note of 8000 cycles per second (over an octave above the top of the keyboard) it is very sensitive, but responds by entirely random nerve impulses of no particular frequency; but to a note of 8000 cycles with a modulation frequency of anything up to 300 cycles it responds by impulses which are regular and in phase with the modulation.

Since the human ear has very little power of appreciating modulation it is easy to see how an insect might distinguish between two noises that seem identical to us. The analysis of the sounds produced by insects ought, in the light of this theory, to produce some interesting results.

D. A. W.

(*Pumphrey and Rawdon-Smith, Cambridge*)

A NEW STEEL

A NEW alloy, known by the patent name of Ledloy, is likely to become of increasing importance in the future. This material, which is a steel containing a small percentage of metallic lead, depends for its ease of machine working upon the lubricating effect of the lead. It would not be accurate to apply the term "solid solution" to this

alloy, since the lead appears to exist, in the cold, in a very finely divided state of submicroscopic size.

Research into the inclusion of lead in steel was suggested by the analogy of brasses and bronzes containing lead, which have an increased machinability. The problem was complicated, however, by the fact that at the temperature of molten steel, lead begins to volatilize (incipient boiling-point of lead being 1525° C.). Eventually a process of adding powdered lead to the molten steel was evolved. Although a certain amount of the lead becomes volatile, a sufficient percentage is absorbed by the steel, and on cooling, an even distribution of lead throughout the mass is found to exist. The comparative machinability is improved by as much as 60 %, and it is found that the life of tools used in machining the steel is increased by as much as 100 %.

W. E. D.

(*Science News Service*)

"CAVE BEAR CULTURE"

In recent years the Cave Bear has become the most fashionable animal in prehistoric studies on the Continent. All talks on palaeolithic and protolithic civilization are suddenly as full of Cave Bears as the caves examined are full of their bones. In a single cave there are from 500 to 6000 bear skeletons, and in some cases they constitute 95 or even 99% of the total fauna. In some caves there are layers up to 12 m. thick, all filled or at least pervaded with skeletons. These layers permit the following up of the entire development, from the primitive bear to the Cave Bear and then to a highly specialized descendant of this animal.

The Cave Bear needed a warm climate; consequently, when the last ice period approached, he obviously descended from the highest mountains into lower places, for example, the famous "Drachenhöhle" near Mixnitz in Styria, and then further down into the plains. It is supposed that Man always followed the bears, living on them as the Laps live on their reindeer, eating their flesh, dressing in their fur, burning their fat, and using their bones as tools. With the beginning of the Würm Ice Period, the Cave Bear became extinct in Austria.

Ice-Age Man himself has not yet made his appearance in any of the Austrian caves. Yet experts speak of a "Cave Bear Culture" and assert that the creator of this culture would be discovered if enough money could be spent in the search for him. The whole theory is based on the fact that large quantities of bones, which look like human tools, although most primitive and unspecialized, have been found in the caves. The interpretation of these bones as tools has, however, been opposed by Colonel Franz Mühlhofer of Vienna, the discoverer and explorer of a very remarkable "Rodent Layer" in the "Merkensteiner Höhle" in nether Austria. This layer contains an enormous wealth of bone fragments, all of them from very small animals. Among these tiny split bones, Mühlhofer found a great many which have exactly the same form as the alleged protolithic tools. It is not likely that bones of 2 or 3 mm. in length should have been artificially manufactured for instruments, but it is easily conceivable that very small bones could have been split and broken by other animals. This action, however, is not so plausible in the case of bear bones, and, therefore, Professor Georg Kyrle, a pioneer speleologist of Vienna, who died last year, answered Mühlhofer's objection by saying that even if these large quantities of tool-

like bear bone fragments had really resulted from the mere breaking and splitting, this would be evidence of a kind of butchering routine, and consequently of the presence of Man.

G. R.

(*Mühlhofer, Kyrle: Vienna*)

THE LONGEVITY OF OARSMEN

For centuries—since the days of Hippocrates and Gallen—strenuous athletics have been supposed to be harmful. In particular, since its popularization during the last century, rowing has been considered to strain the heart or other organs and so lead to early death. There was considerable discussion and heated controversy some seventy years ago concerning this, but although the extreme attitude—that "no man in a rowing boat could expect to live to the age of 30"—was taken by only a few, yet it was generally agreed that rowing was definitely harmful.

This view has gradually changed however, and now hardly any authority holds that a healthy man may injure himself severely by rowing. The two best known oarsmen of recent years, A. M. Hutchison and Stephen Fairbairn, both of Jesus College, Cambridge, died a short while ago at the ages of 78 and 76 respectively.

But whether some slight impairment of health takes place is a question which is more difficult to answer, and it is necessary to undertake a scientific actuarial analysis of the lives of oarsmen compared with non-rowing men. Such an investigation has recently been carried out on the details known of the oarsmen rowing in the Oxford and Cambridge boat race for the 100 years from 1829 to 1928. It was shown throughout that the mortality of the oarsmen was slightly but consistently lower than that for ordinary insured people. This difference has tended to diminish recently, probably due to improvement in general longevity; in other words, the general decreasing mortality in the population at large is tending to make up for the advantage held by the oarsmen.

So vanishes another "health" fallacy.

J. Y.

(*Hartley and Llewellyn, England*)

HOME OFFICE STATEMENT ON THE SCIENTIFIC SIDE OF A.R.P.

At a meeting of the Watford and District Branch of the Association of Scientific Workers recently, Dr R. E. Stradling, chief scientific adviser to the Home Office on A.R.P., dealt with the experimental work which had been done to test the Government air-raid shelters. Before dealing with the subject he regretted that it was impossible to connect any particular work to a specific armament, but that it was advisable not to publish full scientific results which might be identified with a specific British armament.

He said that the preliminary work on the effect of explosives had been carried out by the research departments of the fighting services, but later the Department of Scientific and Industrial Research, notably the Building Research Station, had been engaged on this work. After referring to his own appointment as adviser to the Home Office in February of

this year, he stated emphatically that Sir John Anderson was not making a mere gesture when he said that he believed in the importance of scientific research into A.R.P. problems. Sir John was eager to accept any help that science was able to give him in his work. "Perhaps I may be able to reassure the scientific world that everything is being done to apply science to this work", he said.

He then referred to the wide terms of reference of the recently appointed Civil Defence Research Committee under the chairmanship of Dr Appleton, saying that although the most urgent problem we had to face was the provision of shelters there was no suggestion that this committee should be restricted to that kind of work alone. The committee, composed mainly of engineers and physicists, would be expanded later to cover all branches of science.

One of the difficult problems apart from shelters was the question of obscuration. The difficulty of this work could be fully understood from the single case of slag heaps which could be seen at night at 40 miles' distance.

Dealing with the structural side of shelters he referred to the three main effects of H.E.: The "wind" effect, the "acoustic" wave and splinters. He gave some idea of the splinter problem by saying that anything left unprotected within 25 ft. of an exploding bomb might virtually be regarded as a direct hit. (In answer to a question he gave it as his considered opinion that many of the casualties in the Spanish War which have been put down to phenomenal blast effects were actually caused by splinters.)

He also gave some details of the pressure gauge used in all these experiments on explosion pressures. He said that the gauge consisted of a disk connected to a piezo-electric crystal. When the disk was subjected to pressure, the pressure was converted by the piezo-electric crystal (quartz) into electricity and transmitted to a cathode-ray tube. The movement of the spark could then be recorded photographically.

By its use it was found that there was first a sudden positive pressure from an exploding bomb, followed by a suction pressure of relatively long duration. The over-all effect was the equivalent of a suction pressure conformable with the experience that a wall was "sucked" rather than blown down by an explosion in most cases.

Experiments with this instrument had been carried out inside steel shelters arranged at various distances from the bomb. It was found that the excess pressure of an explosion outside a shelter was of the order of 50 lb. per square inch, but that this was reduced to about 5 lb. per square inch inside. (This was at 30 ft. from an unspecified bomb; actually a 500 lb. bomb.) Dr Stradling commented that this excess pressure of 5 lb. was of the same order as that met with in the vicinity of a large gun. 5 lb. was considered a safe excess pressure for gunners working heavy artillery.

He said that splinters started with a very high velocity of about 6000 ft. per sec., dropping off to about 4000 ft. per sec. after travelling 50 ft. Dr Stradling said that, in his view, protection against splinters meant also protection against blast.

He said that strutted basements were sound, if the floor above the basement were strutted so that the roof did not break in when the building collapsed and the basement were provided with an alternative exit.

* * *

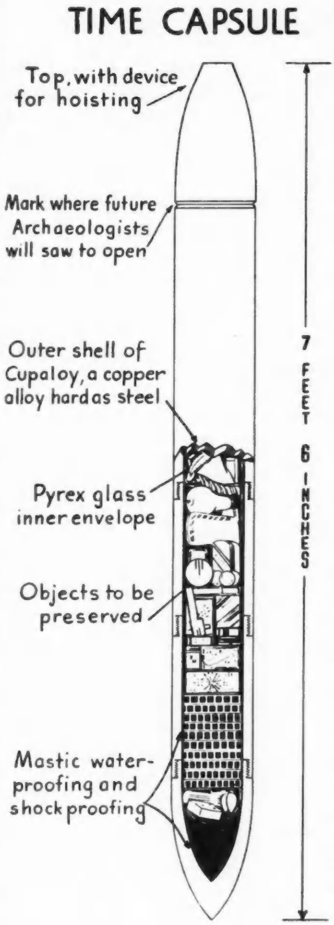
[In our May issue we published a note on "Evaporography". The author has since asked us to point out that p. 242 (5 lines up) should read "...12000 Å (or $1{\cdot}2\,\mu$),...".]

The Legacy of 1939

Buried 50 feet beneath the Westinghouse building at the New York Fair opened in April, there now lies the legacy of our civilization to any who may chance to be alive in A.D. 6939.

The legacy consists of a large torpedo-shaped cylinder, $7\frac{1}{2}$ feet in length and nearly a foot in diameter. Inside are to be found carefully selected samples of those technical and literary achievements of our age which it is thought may be of special interest in the distant future.

In order that generations to come may know the whereabouts of this treasure, copies of a document printed with special ink on pure rag paper have been sent to libraries throughout the world describing where the cylinder has been buried. As rag paper has proved permanent in past ages it is hoped that some of these will survive. Should they do so, futurians will find the position of the cylinder given so accurately that they will be able to locate it to within a few square inches of the earth's surface—assuming they have sufficient skill. In addition, the making of an electro-magnetic instrument is described by means of which the cylinder could still be found if the exact position of Greenwich were to be unknown to future generations. Details of eclipses are also given so that mankind may be able to calculate when 5000 years have elapsed.

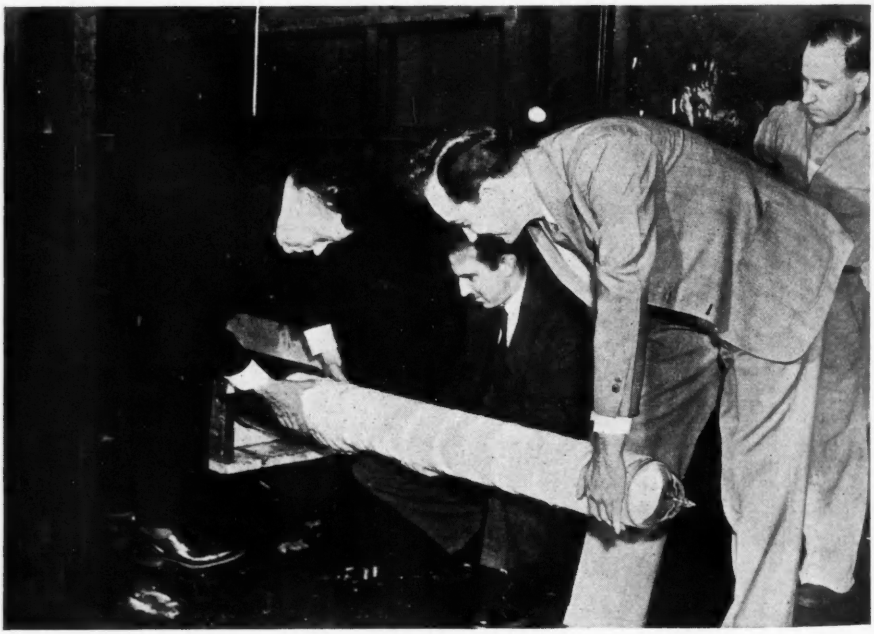


Much thought has gone into the making of the cylinder with a view to ensuring that it may be as permanent and as representative of our civilization as possible. A special hard alloy ("Cupaloy") which is practically proof against corrosion has been used for making the outer case. This was cast in sections, and these were later screwed into one another. Very careful precautions have been taken to prevent the possible entrance of water and to preserve the cylinder from the effects of any sudden shocks such as might be caused by an earthquake at some future date.

The contents of the cylinder are sealed in a large Pyrex glass tube filled with nitrogen gas which has far better preserving qualities than air. In this is a number of objects which it is hoped may throw light upon our age. There are specimens of such everyday things as a pipe, some tobacco (may the futurians enjoy it!), a pen, a camera, a watch, a pair of spectacles, an electric lamp, and even one of the newly introduced electric razors.

The tastes of women are represented by a lady's typical hat and a small supply of cosmetics. There are typical samples of new industrial products such as synthetic rubber and plastics, various alloys, specimens of cloth woven from asbestos fibre, glass fibre and viscose silk, and so on. Commodities which have been in use for generations are also

Some of the objects in the Time Capsule, including spools of rayon, common seeds, film reels, an electric light bulb, etc.



The packed cylinder, filled with inert nitrogen, sealed and wrapped in yards of protective glass tape is placed in the cupaloy outer shell of the Time Capsule

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The Time Capsule descending 50 *feet into the ground*

The Time Capsule on view at the New York World Fair

included, such as natural rubber, wool, cotton, linen, Portland cement, coins, lumps of coal and various kinds of seeds.

Among the most interesting contents of the cylinder are specimens of our literature. Advantage has been taken of recent research at the United States Bureau of Standards which has gone to show that cellulose acetate or "nonflam" film is as stable as the best rag paper. Accordingly, in order to save the difficulty of storing a small library in the limited space available, some typical literary products of our age have been copied on film in the form of micro-copies and placed in the cylinder. Altogether about a thousand pictures and over ten million words have been preserved in this form. Among these there is a complete copy of the *Encyclopaedia Britannica*. There is also a typical American catalogue and a copy of Miss Margaret Mitchell's famous book, *Gone with the Wind*. A microscope is enclosed by means of which the film could be read, but directions are also given for making a satisfactory projector.

In addition to the microfilm there is a typical modern news reel. Should this survive, people thousands of years hence might be able to see and hear President Roosevelt making a speech, to watch Mr Howard Hughes taking off from the ground on his round the world flight, and to join in the enthusiasm of a Soviet Labour Day celebration. They will also be able to see a sample of ideas of humour in the form of a Walt Disney Donald Duck film.

In case the English language should have

been long since forgotten various linguistic keys have been enclosed. There is a multi-language dictionary and a straightforward key to English which should help philologists of the future. With the preservation of the sound films the exact pronunciation of English—or, shall we say, American—should long outlive the present generation.

Thus, filled with what may one day be deemed priceless treasures, this cylinder was recently lowered into a well to be covered with mud for countless years. The American nation has sought to leave to posterity this record of the modern world which, long after our civilization has perished, may one day cause a world sensation.

Having described this Book of Record, it is, perhaps, worth while speculating just for a moment on its future history.

To begin with, we may be reasonably certain that the cylinder will not be opened in A.D. 6939! Our archaeologists would scarcely restrain their curiosity were they to find such a legacy in the tombs of Egypt for the sake of a few hundred years which had yet to elapse, and we can scarcely hope that the archaeologists of the future will be any more willing to wait. More than likely the cylinder will be unearthed in a mere century or two should historians feel the need for examining its contents!

But, perhaps, there are graver dangers. Judging by the present trend of events we can scarcely doubt that if futurians start excavating they will unearth shells and torpedoes in countless numbers. In thousands of years otherwise safe explosives may be in a very unstable state, and, after they have extracted their toll of lives, all objects resembling them in shape will come to be viewed with grave suspicion. So the finders of our legacy may deem it advisable to sink our Book of Record in the ocean with all speed rather than risk the operation of cutting it open. If that happens these our labours will have been in vain!

R. E. D. CLARK

War Films and Child Opinion

By FREDERIC EVANS

(*Director of Education at Erith, Kent*)

LETTERS and articles expressing concern as to the effect of war films, pageants, military reviews, etc., upon child opinion on war and peace frequently appear in the press. There are usually two views to the question which are diametrically opposed. Some see in the films of naval and military reviews a sinister attempt to make us militaristic in the aggressive sense or to produce attitudes favourable to war. Others hold that these spectacles are interesting as spectacles only and do not feed the combative tendencies which may be present in man.

Clearly only an objective study of child opinion in relation to war films and the like would be of any value in this controversy. For the last fifteen years or so the schools, encouraged by the teachers' associations, by the education authorities and by the Board of Education, have been directing their curricula towards the growth of knowledge about the world as a community, with the effect, it was hoped, of producing a basis of opinion favourable to the collective system of organizing for world peace. It would be interesting to discover how far in Britain this new trend

in education for a changing world would offer resistance to other ideas that might be engendered by films and pageantry connected with war and warlike preparations.

Two investigations have recently been carried out to obtain some objective evidence on this point. In one of them films were used as the test material. The films used were official films of the War taken about 1916 and 1917, which were extensively shown during the Great War in public cinemas in England with the view of encouraging the *morale* of the people in support of a strenuous prosecution of the War to a successful conclusion. These films, whilst showing the more respectable horrors of war, were in fact propaganda for those times. They showed the Battle of the Somme, operations in the Near East and Naval and Air Force activities.

These were shown to four hundred boys and girls in Central Schools who were round about thirteen years of age.* No comment on the films previous to the showing or afterwards was made by the teachers to the children concerned. The enquiry was directed to find out whether the teaching in the schools in support of the idea of a world community could withstand the effect of the films which were propaganda during the War. No control tests were made as would have been necessary in a more detailed investigation. It was felt that the work of the schools in this connexion was very well known, so that tests after seeing the films only, were made in order to discover whether there was any general pro-war tendency in the children's opinions after seeing the propaganda films.

The immediate reactions of the children as they viewed the films were to peace lovers apparently disquieting. The children cheered the men "going over the top" in the Somme battle. Some of them laughed at the limping, blinded "walking wounded". The generals, admirals, airmen and the great battleships all came in for hearty cheers. Pressmen who were present gave their opinions in their reports that "the children would go to war to-morrow joyfully".

The tests reflected quite another attitude. The cheering of things which were to the children cinematic, did not mean that they wished these conditions to come again and to apply them. Laughter at grotesque wounded was really an "escape mechanism" rather than a lack of sympathy. The real and considered opinions of the children were those given in their replies to the two questionnaires set them, one immediately or soon after the films were viewed and the other a few days later. Perhaps the simplest way of giving an analysis of the children's replies is to show a tabular form:

QUESTIONNAIRE PAPER I

You have seen films and pictures which were actually taken during the Great War of 1914–18. If you remember what you saw in these pictures and what you thought about them, you will be able to answer these questions:

Question 1. "WHAT DO YOU THINK OF WAR?"

Replies favourable to war	Replies against war	Indefinite
1	381	1

These figures need no comment.

* Erith, Kent.

Question 2. "WOULD YOU LIKE TO SEE ANOTHER WAR COMING?"

Yes	No	Indefinite
1	382	0

In spite of the "propaganda" value of the films seen, here is a devastating reply to the suggestion that the children cheer war scenes because they want war, and would welcome war. The same girl gave answers favourable to war in both Questions 1 and 2.

Question 3. "WHAT DO YOU THINK OUGHT TO BE DONE?"

Main types of reply	Total
Disarmament, reduction and control of arms	123
League of Nations	122
Arbitration conference, treaty	85
"Keep the peace"	54
Fraternity, thought, etc.	39
International police force or joint force	28
Indefinite: Anti-war	21
Pro-war	2
Pacifist view	17
"Try and stop it"	14
"Prepare for war to keep peace"	15
Religious action	4
"Show war horrors"	4
Establish world courts of law	4
"Those who make it, fight it"	4
Fight	3
"Economic boycott"	3
World empire	3
Destroy dictators	2

Significant features of the figures in the analysis of these replies to Question 3, Paper I, is the high scoring of the idea of "Disarmament" in an area interested in the manufacturing of munitions like Erith. Another feature is, whilst there is some support to the idea of an International police force, the necessary corollary of a World Court of Justice is almost uncanvassed. This is an omission in the discussion of the problem which clearly needs remedying. A feature, too, of the figures is the low frequency of replies indicating belief in religious methods of combating the idea of war. Are the wars of religion in the school text-books partly responsible for this?

Question 4. "IF ENGLAND WENT TO WAR WITH ANOTHER COUNTRY, WHAT WOULD YOU DO—IF YOU WERE GROWN UP?"

Affirmative replies

Would render assistance			
Unconditionally	If conscripted	If cause just	Would serve as non-combatant
266*	16	17	10

Total 309

* This figure includes certain girls twice over, under heads both of Munitions and Nursing.

Indefinite Replies

Would advocate peace	Would carry on	Would fly for safety	Would help suffering people
89	9	19	16

Total 133

Negative Replies

Would not render assistance

Complete negative	Conscientious objections
20	12

Total 32

These figures show a majority in favour of co-operation in the event of the emergency of war, yet a total of 199, between one-third and a half, are in fact against unquestioning co-operation.

The figures also seem to show that the idea of national loyalty is well established, but that it is hoped it will never demand the sacrifice of war. Such expressions in affirmative replies as the following were frequent: "I would fight in defence of my country, but with the League of Nations (or arbitration, or common sense) it ought not to be necessary." An interesting fact is that all (20) who gave completely negative answers were boys.

QUESTIONNAIRE PAPER II

Question 1. "HERE ARE A NUMBER OF ADJECTIVES, OF WHICH SOME DESCRIBE WAR, AND SOME DO NOT. CROSS OUT THOSE WHICH DO NOT."

Remaining words:

Horrible	380	Heroic	182
Dreadful	362	Thrilling	59
Wicked	354	Glorious	9
Savage	333	Wise	9
Foolish	285	Splendid	4
Useless	280		263
	1994		

The "anti-war" words score heavily against the "pro-war" words. "Heroic" is neutral. War can be heroic, but clearly there is not present the general opinion that it should be conducted in order to give opportunities for heroism.

Question 2. "CAN YOU THINK OF A GOOD REASON FOR GOING TO WAR?"

	Total
Affirmative replies	165
Negative replies	211
	376

Main types of reason given	Total
Affirmative	
Defence	76
To stop aggressor	23
To increase employment in munitions	20
Conquest	17
To demonstrate the foolishness of war	16
To defend treaties	8
To settle disputes	8
To encourage heroism	8
"To make for unity"	5
To enforce peace	4
To give discipline	4
To protect trade	4
Negative	
Waste of life and treasure	29
Too stupid	12
Why not arbitrate?	5
Too horrible	2

(The negative answers were, generally, a plain NO.)

In this case many of the children seem to have been misled by the form of the question. They have, in their replies to this query, attempted to find reasons because they concluded from the form of the question that they were bound to find reasons, although large numbers qualify their positive, for example, by saying "I can only think that going to war is right when you have to defend yourself against attack—but with arbitration it ought not to be necessary."

Even so, a majority of definitely negative answers was obtained. Few children emphasized the idea of "good" in the sense of morally "good". It was clear that the causes of war in history were in some of the children's minds when answering this question.

Question 3. "WHAT DO YOU THINK YOU WILL REMEMBER BEST OF ALL THE THINGS YOU SAW OF THE FILMS AND PICTURES OF WAR THAT YOU HAVE SEEN?"

Main types of answer	Total
Dead, wounded, horrors, etc.	175
"Going over the top"	63
Ambulance work	59
English and Germans helping one another	57
Cheerfulness and bravery of the men who fought	48
Dead animals and horses	40
Guns	38
Bombs	21
Ships	15
The trenches	11
After the battle	11
Aeroplanes	10

The mines	10
The discomforts	9
Destroyed homes	5
The waste	3
Prisoners	1

The horrors of war even as mildly presented as they were in propaganda films seem clearly to stand out as the main reaction.

Two interesting figures are those for interest frequencies in ambulance work, and in the English and Germans helping one another.

Considerable interest was also shown in the sufferings of animals, whilst "going over the top" and the firing of great guns have had, naturally, a fascination. The gunners of the Great War were the least savage of men—they were essentially technicians, not combatants.

Question 4. "WHAT COULD BE DONE TO KEEP WAR FROM EVER HAPPENING AGAIN?"

Main types of answer	Total
League of Nations	151
Disarm	148
Friendship and peace	83
Arbitration conference and treaty	58
United world	27
Fight aggressor	14
"Can do nothing"	10
A plebiscite, or peace ballot	7
World conciliation	6
Pacificism	4
Use religion	4
International police force	4

These are interesting figures. This delayed questionnaire gives an even greater reaction in favour of the League of Nations, and of Disarmament than was the case in Question 3, Paper I. This is evidence of these deeply ingrained ideas as a result of consistent teaching. But here again, ideas of World Law are almost non-existent. Religion scores only 4 in both cases and in this paper the idea of "can do nothing to stop war" (10) has crept in, and one wonders whether the film exhibition caused discussions in the homes, and by the second paper certain parental opinions are now definitely expressed. References to the idea of a peace ballot in view of the National Peace Ballot were surprisingly small. Only one believed that increasing armaments would make for peace.

The general conclusion is, that in spite of much which may be feared to be war propaganda—pictures of reviews, tattoos, air displays, Navy weeks, etc.—the real opinion of the young generation as to the undesirability of war is sound. The change of attitude in the teaching of history, geography and other subjects in the curriculum, and the emphasis laid in direct instruction on the League of Nations,

etc., in the schools during the last ten to fifteen years, are clearly having their effect upon young opinion, and there is far greater evidence that young minds know of, and are more ready to accept, the idea of world peace through collective action than there would, it is believed, have been in 1913. There was evidence that the children showed increasing thought and concern with the problem of peace as they grew older.

An education of wider sympathies and of greater knowledge of the machinery of international government which the world laboriously, and in spite of many set backs, is building up, is clearly bearing fruit. The propaganda film—essential as it might have been in the emergency—is no longer propaganda to a new clear-eyed generation in whose hands, if the old pre-war mentality can be held in check for just a few years longer, the responsibility for world peace is safe, at any rate as far as this country is concerned.

These conclusions were borne out by an investigation undertaken by Mr P. Edmonds, M.A., of the London Institute of Education, who, with control groups, tested children before and after attendance at a full military review of all modern arms of the service. Mr Edmonds found the same vast body of opinion in the school children in favour of co-operative and sane methods of conducting world affairs. Whether these opinions would succumb to the emotional appeal of a call to arms is not known; at any rate we can safely assume that little belief in aggressive and imperialistic war exists in the young people of to-day in Britain.

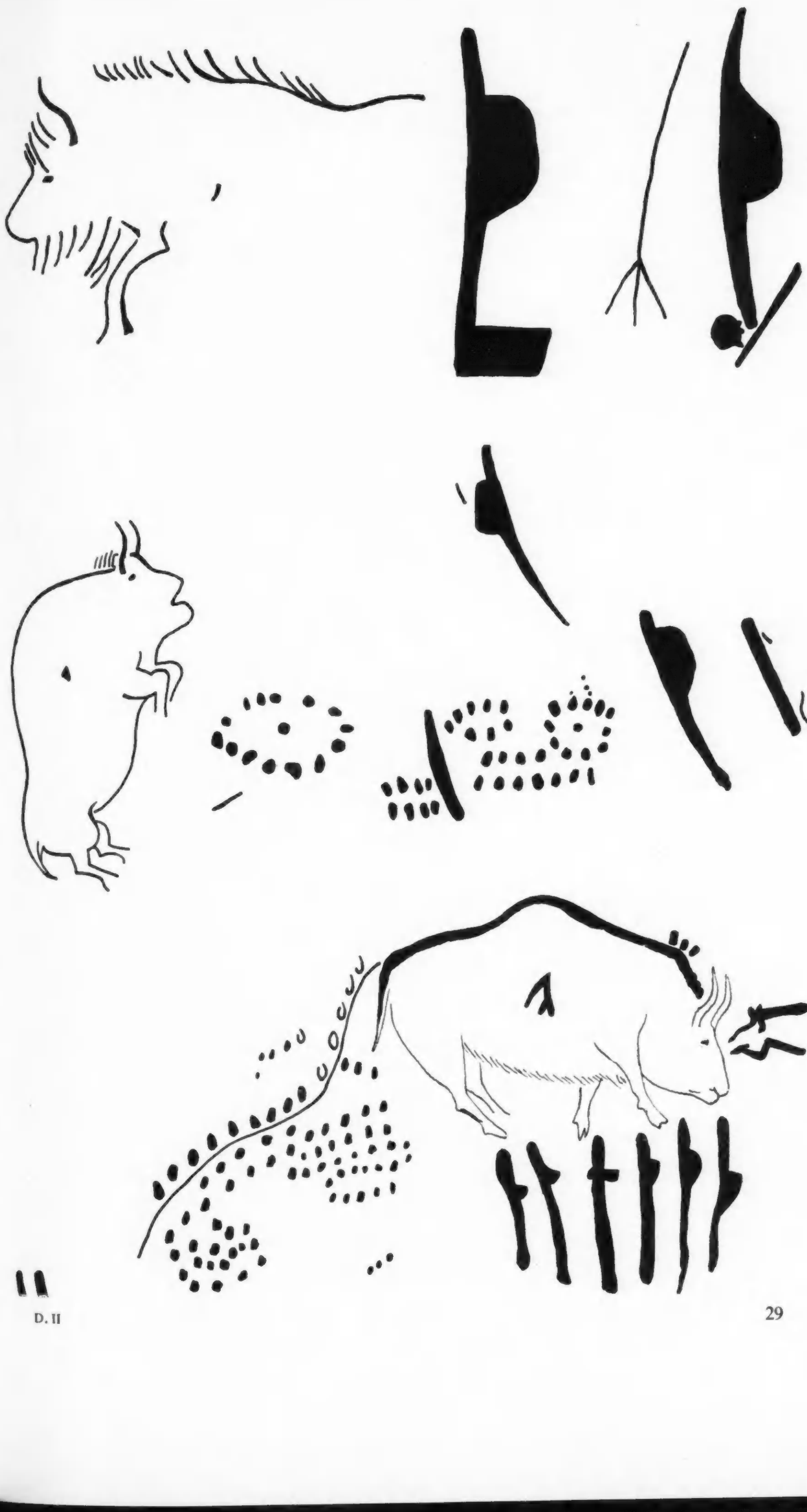
"Scarecrow Magic" in the Ice Age

By Dr Gabrielle Rabel

In the "Merkensteiner Höhle" in Nether Austria, mentioned on p. 348, little pebbles were found which proved to be gastroliths from ptarmigan crops. This find led Colonel Mühlhofer to the conclusion that charred wheat grains, also found in the cave, had the same origin. These grains were obviously picked up by the fowl at the camps of Glacial Man. From the ptarmigan crop, they wandered with their host animal into the snow owl's crop, nesting in the cave, which left its cast-up pellets there. The grains were botanically determined as dwarf wheat, *Triticum compactum*, a variety which is particularly suited to rough climates.

This confirmation of the fact that Ice Age Man already cultivated cereals, inspired Colonel Mühlhofer to a renewed examination of those famous paintings and etchings which have been found in the caves of southern France and Spain. He decided that certain pictures showing such animals as bisons need not necessarily depict hunting scenes. In addition to the "Hunting Magic", there may have existed a "Scarecrow Magic". Hunting magic means that in the morning a hunter would try to make sure of his success by painting an arrow on to a picture of an animal of the same species as he desired to kill.

Now some pictures found on the walls of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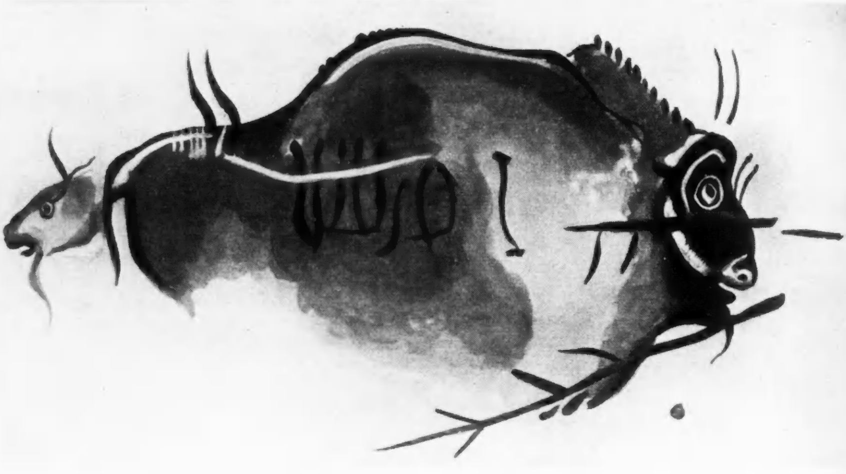

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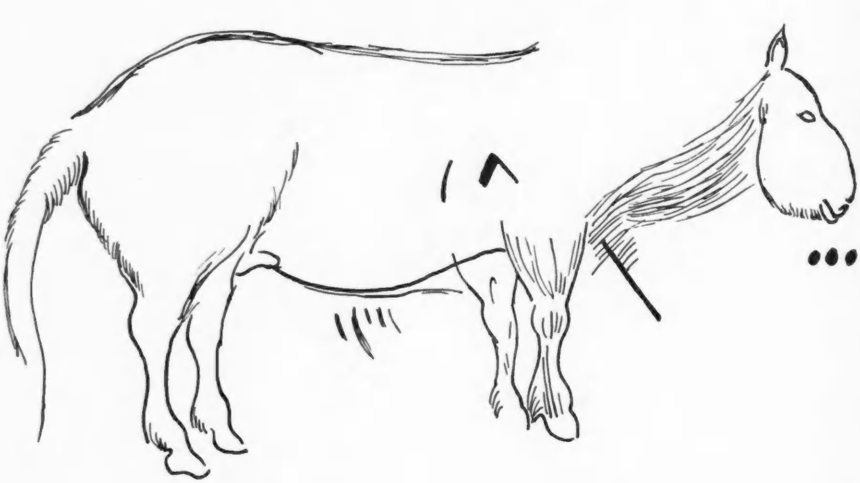


caves show a number of red painted hands or other signs which Mühlhofer interprets as warning animals not to enter man's fields. Plants are represented by the conventional tree symbol, as in Fig. 1, and fields by a collection of dots as in Fig. 2. The magic black signs, whatever they may mean, are supposed to have an overwhelming effect on the animal, which, in Fig. 2, stands in awe, not daring to approach the field, and in Fig. 1 runs away at full speed. In Fig. 3 the bison disregards the warning signs and runs through the field, with the result that he incurs the death penalty, which is indicated by the point of a spear in his body. The same is to be said of the bison in Fig. 4, in which the animal is seen to be breaking through a fence. This one is particularly interesting artistically. In Fig. 5 the act of feeding is symbolized by the three dots in front of the mouth of a wild horse, and again the punishment appears in the form of a lethal weapon in the body of the animal.

Letters from Readers

Mr Tompkins' Bicycle Troubles: An Explanation by Professor Gamow

(In the story of Mr Tompkins' third dream (Discovery, *vol.* II, *no.* 11), *Mr Tompkins experienced certain difficulties in accelerating his bicycle. It has been pointed out to the author that the difficulties were really more intricate and complicated than those discussed in the story, and a somewhat more detailed analysis of the situation might therefore be of interest.)*

THE ordinary relativistic increase of mass with velocity of a moving body refers usually to the observations made from the system of reference relative to which the body in question is moving. If, for example, standing in a bowling alley, we try to roll a ball really fast, we notice that the resistance of the ball against further acceleration will increase above any limit when its velocity approaches that of light.

In the case of Mr Tompkins trying to accelerate the bicycle *on which he himself is sitting* the observations are made from the moving system of reference and the question of "getting up speed" arises. In the ordinary world one can measure the speed of the bicycle on which one is riding, either by noticing how fast a stationary object relative to the street, say a lamp-post, is moving by, or counting the number of revolutions of pedals (provided the bicycle has no free-wheeling device).

In the relativistic world these two methods will, however, give rather different results. In fact, owing to the transmission mechanism, a comparatively slow motion of the pedals will correspond to a very fast rotation of wheels, resulting in relativistic contraction of their rims. Thus, with increasing velocity, the distance covered by the bicycle per revolution of pedals will decrease and tend to zero when the velocity of the bicycle approaches that of light. On the other hand, the apparent length of the city blocks will decrease correspondingly, so that the number of pedal revolutions necessary to pass a given number of blocks remains constant. Sitting on such a bicycle Mr Tompkins could rotate the pedals very quickly indeed, but his velocity relative to the street would change only very little. He would think either that something was wrong with the transmission, or that the wheels were sliding as if on an icy pavement.

If he measured the difficulty of "getting up speed" by his efforts (energy used) necessary to increase the velocity relative to the street by a certain percentage, he would find that *this difficulty increases above any limit when the velocity of the bicycle approaches that of light.*

If, however, he cares about rotating the pedals faster (paying no attention to the resulting change of velocity), he can always do it without much effort. It might seem at first sight that such "pedal speeding" unaccompanied by an increase of actual velocity is quite a useless occupation, but it is not quite so. A given number of pedal revolutions takes him along for a certain number of blocks; turning the pedals twice as fast, he will arrive at his destination twice as quickly. These result, as explained later in the story, not from the increase of relative velocity (which remains almost constant), but from the relativistic shortening of distances. Thus the existence of the relativistic "speed limit" will not make it any more difficult to get anywhere as fast as one wishes. In fact, it will make it even easier than in the classical world as can be seen from the following considerations.

If, riding a classical bicycle, we press

twice as strongly on the pedals, the energy given to the bicycle during one revolution of the pedals will be twice as large. As in classical mechanics the energy of a moving body is proportional to the square of velocity, the velocity of the bicycle will increase only by a factor $\sqrt{2}$, and we get to our destination $\sqrt{2}$ times sooner. In the relativistic world, the increase of energy of a moving body is governed by the same factor ($\sqrt{(1-\beta^2)}$) as the decrease of distances, and, if the energy were increased by a factor of 2, we should arrive at our destination twice as soon. Thus a cyclist interested only in the time it takes him to arrive at his destination *will find it easier "to get up speed" in the relativistic city*.

It should be indicated, however, that neither of the two methods given above represents the correct way of measuring the "mass" in the moving co-ordinate system, because in both of them the reference is made to the observations of objects resting in the street. To measure the mass of his bicycle properly Mr Tompkins should use only the objects moving with the same speed as his bicycle in the moment of acceleration. For example, he could hold on to a lorry driving rapidly down the street, and then try to pull himself forward closer to the lorry. The resistance he would meet in such an experiment would give him directly the mass of his bicycle (including himself) in the moving co-ordinate system. As far as, according to the fundamental principle of relativity, it is impossible to notice the relative motion by the measurements performed inside a uniformly moving system, the mass thus obtained will always be the same as in the resting system of reference. Thus Mr Tompkins *would not notice any increase (or decrease) of difficulty in accelerating his bicycle relative to the lorry, however fast it might be pulling him along*.

In conclusion, it should be noticed that in all the above considerations we neglected the relativistic effects in the moving parts of the bicycle. Such effects have no immediate relation to the motion of the bicycle (they would be unchanged if the bicycle were suspended on ropes), and their introduction would make the whole problem still more complicated.

"Spacequakes"

IT is satisfactory to a mere amateur to find his ideas endorsed by specialists.

In my *Autumn Leaves*, published in 1928, I broached the idea of a "spacequake" as the cause of all the commotion we see in the universe, and in *Discovery* for May, 1939 I see Professor Gamow uses this same term in relation to "funny changes in the curvature of space".

May I go one step further and suggest that the alternative positive and negative curvatures of space are due to the "breathing" action of the universe following the shock of the "spacequake"?

This idea receives support from the conclusion that space is solid, which, I understand, is now regarded by metaphysicians as established.

Further, I would like to take this opportunity to seek enlightenment from someone possessed of greater mathematical ingenuity than myself to solve the following problem:

If I divide 200 by 10 I get 20.

If I divide 200 by 20 I get 10.

If I divide 200 by 15 I get 13·3 (recurring). Why not 15?

15 only comes out by dividing by 13, and then is not an even number (15·3846).

Somehow it must be all right. But the *reason* is not apparent.

E. CHALMERS WERNER, Peking, China.

The Water Level of Lake Victoria

IN a letter in your May issue Mr Deeley states that: "It has been shown that the water level of Lake Victoria in central Africa rises and falls in agreement with sunspot periods."

This question is discussed by Hurst and Phillips in *The Nile Basin*, vol. v (Cairo, 1938). Several correlation coefficients based on recent information are given, which show that "the high correlation which existed between lake level and sunspot numbers for the years 1896–1922, which were used by Dr Brooks, has practically disappeared for the subsequent years 1923–1934. Neither is there any correlation between sunspot numbers and change of lake level or rainfall. No long series of evaporation observations has been made near Lake Victoria, but the correlation between sunspot numbers and evaporation at Mongalla, the nearest station for which a long series of observations exists, is practically zero over a period of 26 years. In fact, the only correlation which remains is the straightforward one between rainfall and change of lake level. The conclusion is that a connection between sunspot numbers and the levels of the great lakes of the Nile basin has not been proved."

This rather long quotation is taken direct from *The Nile Basin*, and may be of interest to readers of *Discovery*.

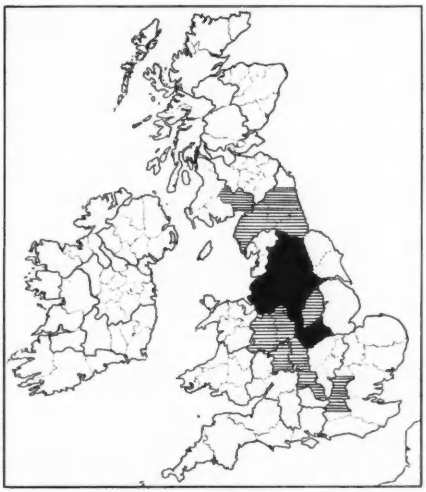
L. J. SUTTON, Cairo.

Flower Problems

(*In his article in our May issue, Dr D. H. Valentine asked readers of* Discovery *for their help in solving the problem of the Butterbur. Some interesting and important letters and specimens have so far been received, and these are acknowledged in the note below.*)

I HAVE received several interesting letters relating to the article on Butterbur in May's *Discovery*. Perhaps the most important of these was from E. Whitworth, who reported female butterbur at Dalry, in Ayrshire. This is a new vice-county record, and a new northern limit for the female plant in Britain. Other new records have been obtained from Lancashire, Cheshire and Yorkshire—a particularly important one from Whalley in North Lancashire. Correspondents have also sent interesting biological notes with their specimens.

I should be glad to have new records from Central and Southern England, where female butterbur is scarce; it is only when the records of the distribution of a plant and its habitats are complete that we can begin to explain the distribution, to correlate it with climatic factors, and to compare it with that of other species. I am very grateful to readers of *Discovery* for the help they have given so far, and I hope they will continue the good work.



Map showing distribution of the female plant in England

D.H.V., Botany School, Cambridge.

A WORLD OF ITS OWN

Sea Life at a Depth of 600 metres

BY modern improvements upon the old diving bell it has been found possible for observers to descend into the sea to depths of 600 metres. The difficulties to be overcome may be realized when it is understood that the human body cannot stand a pressure greater than 2·8 atmospheres, and that pressure increases under water by one atmosphere for every 10 metres of depth. The modern hydrosphere, large enough to contain a human observer, is designed to withstand heavy underwater pressures, and to allow observations to be made through windows. The American biologist, William Beebe, was the first person to risk descent to these great depths. He has published many photographs and observations taken at a depth of 400 to 600 metres. They tell of a world so grotesquely strange to us that they seem to belong to some other planet.

Like nightmare creatures the queer luminous fish thread their way through the sea's deep darkness—for the rays of the sun cannot penetrate to more than 30 metres. There is no plant life at these low levels, and all the inhabitants must prey upon each other for their livelihood. They are armed for this purpose with strange weapons; some of them carry a phosphorescent lure with which they attract their victims; others, such as the Sea Dragon, have developed enormous teeth by which they can attack and devour fish even larger than themselves. These things can only be studied at risk of life in the depths to which they are native; for if they are brought to the surface the release of pressure instantly destroys the living tissues. The floor of the sea, in fact, is a world to itself, and must be studied under its own conditions.

Black pirates of the ocean depths: "Degraded eels", one of which (top right) has just swallowed a fish bigger than himself, stretching him nearly to his elastic limit, while "his less fortunate mate, yawning fearfully, opens the dark gateway to his cavernous interior"

Fishes wandering to and fro about the skeleton of a whale on the ocean floor

Little sea-d
attract their
the luminous
rod above th
mouth

Reminiscent of a C
nese painting: a mi
ture dragon of the d
sea. A Chaulio
approaching peac
Melamphids

←

Little sea-devils that attract their prey by the luminous tip of a rod above the gaping mouth

→

Reminiscent of a Chinese painting: a miniature dragon of the deep sea. A Chauliodus approaching peaceful Melamphids

Weather and Disease

By Reginald M. Lester

Medical experts are agreed that certain types of weather are productive of specified diseases, and that the relation between weather and disease is far closer than is commonly realized.

The effects of climatic environment must be considered both from the viewpoint of indoors and out, but the former are now very much improved by modern methods of air-conditioning, heating and ventilation. It has been found that a regular temperature of approximately 65° F. is ideal for indoor office workers, but different conditions are naturally required for varying kinds of indoor manual labour.

Humidity is an important factor in relation to health, whether it be humidity in our homes or work places, or in the particular district where we live, or at the resort where we decide to spend our brief summer holidays.

Temperature has a bearing on the degree of humidity. For instance, a cubic foot of air at freezing-point only contains a *maximum* of 2·1 grains of humidity; if, however, the air temperature were as high as our body temperature (i.e. 98·4), the humidity would rise to 18·7 grains. It will be realized, therefore, that if we inhale air at freezing-point temperature, it becomes warmed up in our respiratory passages to the temperature of our body, and on its expiry again takes from such passages 18·7 minus 2·1 grains of water, or about 16½ grains in all. Nasal catarrh will result, if this moisture is not replaced sufficiently quickly.

The value of a district's relative humidity, therefore, is of primary importance. Unfortunately, humidity statistics of many resorts, advertised in the Press, in town guides, or in railway brochures, are not very reliable. The reason is that the readings are only taken three times a day—at 7 a.m., 1 p.m. and 6 p.m.—in most cases. This leaves the most important period entirely uncovered, which is from sunset to sunrise, when the humidity in certain districts rises to more than double that during the daytime. The sufferer from an ailment that is adversely affected by high humidity, therefore, who selects a district where the humidity is advertised as "only 40%", will find that he is actually sleeping in a humidity of probably over 90%, and it is during sleeping hours that the greatest curative effects should be in operation.

Very dry, hot air is as injurious as over-humid air, as it affects the mucous membranes considerably. For that reason, central heating without adequate ventilation or air-conditioning cannot be recommended for either domestic or business buildings. Although houses in this country are not over-heated by steam coils to the same extent as American homes, it cannot be denied that central heating of this type *does* lower the humidity below health minimum. This is even more so in some public institutions, such as music academies, where windows must remain closed to prevent sound escaping to the possible annoyance of adjoining dwellings. In some of these buildings, central heating reduces the humidity to as low as 20%; compare this with the dry heat of the Sahara Desert, where the humidity is no lower than 30%.

Central heating by means of electric coils instead of steam overcomes this disadvantage of humidity reduction considerably, but electric central heating does not seem to be as widespread at present as steam. We hear a great deal to-day about smoke abatement, and how the open coal fire—still beloved by the average Englishman—is responsible for air pollution, but we are rarely told that the open fire is the

healthiest form of heating for the home, and tempers the humidity and ventilation of a room to an ideal degree.

The humidity of the atmosphere affects the loss of heat by evaporation from our lungs and skin, which regulates our body temperature. Very low humidity produces too high an escape of water from our bodies, in the same way as too high humidity allows too low an escape of body evaporation. We are all familiar with the oppressive type of summer weather when thundery conditions are pending, and the free escape of body heat by evaporation is prevented. When we perspire, the moisture passes to the surface of our skin and is normally evaporated, thus having a comforting cooling effect later. But the cooling effect is prevented when the air humidity is unduly high as well as the air temperature.

Atmospheric conditions have been proved to have a considerable effect on specific diseases. Prof. W. F. R. Phillips, the American scientist, asserted that sudden temperature changes particularly affected persons suffering from kidney trouble or high blood pressure. The peripheral blood vessels contract and increase the blood density and pressure, and their subsequent relaxation is not nearly so speedy as their contraction. Consequently, the volume of blood in the kidneys is unduly increased, and the velocity heightened. The normal evaporation of the skin then devolves on the kidneys.

Sufferers from these diseases, therefore should avoid districts that are subject to extremes of temperature, which are usually to be found in the valleys. Higher altitudes, or coastal resorts, are not usually subject to such fluctuations of temperature as inland valley localities.

* * *

Comment is frequently made on the fact that a day with a cold wind and an average temperature produces a greater feeling of cold within one's body than a day with a much lower temperature but an absence of wind. This is because the wind lowers the temperature of the body even though it does not cause the air temperature to fall. If we are in good health, the only effect is a feeling of uncomfortable chill, but to others it will adversely affect the kidney cells.

It has been found that Bright's disease is curable under suitable climatic conditions, which must comprise a dry, warm and sunny air, an absence of high rainfall, and small temperature fluctuations. Moderate elevation is also favourable, but not an unduly high altitude—especially in the case of old people. If one suffers from heart trouble, the nearer to sea-level the better, as the higher the altitude the greater the heart strain.

If kidney disease has progressed too far, of course, no kind of climate or treatment will cure it, but if taken in its early stages, it may be arrested and finally overcome. The ideal climate is stated to be one that approaches as near as possible to the conditions of California; many American citizens suffering from chronic kidney disorder have gone there and been cured.

We cannot all find a Californian climate within access, but we can select one which approaches it as near as possible, such—for instance—as parts of the Cornish Riviera.

Although cold is detrimental to all renal troubles, more illness is caused by heat than by cold. In this country, deaths from heat exhaustion or sunstroke are very much less than on the continent, and usually occur when we have experienced a heat wave that lasts for several consecutive days—not a particularly frequent occurrence. Statistics show that alcoholism and overwork are the main contributory causes to heat deaths, as they cause diseases of the circulatory system.

Heat stroke need not necessarily arise from exposure to the sun; stokers in the boiler rooms of great liners or naval ships are subject to this, and the symptoms resemble ordinary sunstroke almost identically.

A good deal of investigation has taken

place into the types of weather responsible for pneumonia, influenza and allied illnesses. It is generally agreed that sudden changes of temperature are more detrimental than a steady, continuous cold, especially in the case of lobar pneumonia, and for that reason the spring months in this country are most treacherous—especially a normal April. It is also an interesting fact to note that the mortality rises and falls in ratio with the barometric pressure; the greatest mortality occurs when the barometer is at a period of high pressure, and falls as the barometer settles to a low period. This is probably because a high barometer in winter is usually coincident with severe weather and north-east winds, so that the mortality tables are very uniform with the movements of barometer, thermometer, and wind direction. In fact, pneumonia epidemics are extraordinarily consistent with the arrival of "cold fronts" on our shores.

* * *

Influenza epidemics, although seasonal, are not considered to be due entirely to direct effects of cold weather, but more to the lack of solar radiation, and the increased bacteria in our homes arising from the tendency to close windows and exclude the pure air in wintry conditions. Certain German scientists have also suggested that topographical variations determine such epidemics, and in confirmation have pointed out that they are particularly prevalent in the mountain-enclosed valleys. Stationary anticyclones, which incline to stagnate the air, are also blamed, owing to their low subsidence inversions. Probably the worst influenza epidemic of recent times was that of 1918, both in this country and abroad. In Great Britain, 151,446 people died from it, and in the U.S.A. more than half a million. Mortality was also high in France, Spain and Russia.

* * *

Very little advance has been made in research into the common cold, three of which the average person is estimated to have per year. It cannot be stated with any degree of certainty whether it is brought about by external weather, indoor conditions, the kind or amount of clothing worn, or wrong diet. Various attempts to correlate the common cold epidemic with outdoor weather have been quite unsuccessful.

Diarrhoeal diseases, however, seem to have a more definite correlation with weather. They are more prevalent in hot weather than cold, and consequently in summer than winter. Bacteria, of course, more readily produce fermentation in food in hot weather, which so often leads to this trouble, and heat lowers the resistance of the body as much as cold. Intestinal diseases, however, are much less now than they were a few years back, owing to the advance in public health services.

Diseases in our colonies are very closely related to weather phases, especially such illnesses as cholera and malaria. In India, cholera increases regularly when the autumn and winter rainfalls are below normal. Many diseases in this country can be traced to tropical origin, and in this respect the work carried out by the school of tropical medicine in London is of inestimable value.

A better knowledge of the meteorological conditions responsible for many of our diseases, and the most satisfactory ways of combating them, is a subject that is worthy of continued deep research.

The Retirement of Sir Daniel Hall

(In September this year, Sir Daniel Hall, one of the greatest experts on soil problems and plant breeding, retires from the directorship of the John Innes Horticultural Institute.)

It is surely not too much to say that Sir Daniel Hall has been connected with every important development in modern agricultural practice. First as director of Rothamsted, then as agricultural adviser to the Government, and now as director of the John Innes Horticultural Institution, he has been connected with agricultural progress all his life.

After a year or two of schoolmastering, Sir Daniel began to lecture on agricultural science in Surrey, and then became the first principal of the Wye Agricultural College.

It is important to get the scientific perspective of agricultural science at the time that Sir Daniel went to Rothamsted, and it is, perhaps, best to quote his own words here:

"At the death of Sir Henry Gilbert, his great problem, the sources of nitrogen for vegetation, had been solved in its essentials. The famous field experiments had answered the major questions concerning the fertilizer requirements of our farm crops. But the knowledge of the vast flora and fauna of the soil and of their functions, as of the changes in the soil itself due to cultivation and fertilizers, was only just beginning. Rothamsted was ready for a fresh start. But its equipment, both as regards staff and laboratories, was lamentably deficient and out-of-date. Thanks to the generosity of the Goldsmiths' Company and of the late Mr James Mason of Eynsham Hall, Rothamsted was able to add a biological laboratory and to recruit the services of Dr H. B. Hutchinson, now with the Distillers' Association, and of its present director, Sir John Russell.

"Russell had already begun experiments upon the sterilization of soil by heat and antiseptics, which have in one form or another become universal practice in the glasshouse industry. Hutchinson's investigations in the bacterial destruction of cellulose in the soil laid the foundations for the processes of making artificial farmyard manure and composting which are now being widely utilized.

"My own work lay with the interaction of fertilizers with the soil, with the accumulation of nitrogen, and with the loss of lime which the soil suffers.

"The creation of the Development Commission, charged with the reorganization of a scheme of agricultural research, led to my resignation from Rothamsted and eventually, 'under orders' during the War, to my appointment to the Board of Agriculture. It was not until 1926 that I was able to return to the Rachel of research after more than the biblical years with the Leah of administration."

Sir Daniel Hall then turned to the work of plant breeding as director of the John Innes Institution. "Here we are primarily interested in the theory of plant breeding", he said. Those who know the work of Darlington and Crane, and the succession of workers on *Primula sinensis* will realize the importance of the work that has been carried out at this research station. It has placed England in the forefront of genetical research.

"I know some people sneer at the pure scientist", continued Sir Daniel, "but as the originator of the theory he becomes instigator of practical applications. The practical man is by his help saved from many false steps He brings us many of his problems to solve, and we are grateful. For the problems that confront him often provide a lead to the next line of research and the formulation of new hypotheses.

"At John Innes, commercial applications are not our objective, although when working with economic or ornamental plants novelties of value, such as the thornless blackberry, are sure to arise and take their place in the commercial market.

Sir Daniel Hall

"For instance, there is need for some more work in strawberries. The position of the strawberry grower in Great Britain is becoming serious. Unless some more virile strain is produced, they will all go smash, for in many of the strawberry growing

districts the present breeds of strawberry become afflicted with disease within two years of planting."

It appears that the strawberry, like so many other cultivated plants, has a very complicated genetical constitution, and is suffering from breeding too exclusively for one character.

The only salvation, says Sir Daniel, lies in injecting new blood from the old original strawberry stock—the wild strawberries from which the modern strawberry was derived.

He went on to say that with many of our cultivated plants with a long history of interbreeding behind them science can do little more than enable the plant breeder to estimate the odds *against* producing a desired type.

"We cannot tell whether the individual son or daughter of a marriage of a tall father and a short mother will be taller or shorter than their parents; but given 2000 progeny, it would be possible to say what the average height of each sex would be! Of apple hybrids, we can say with some degree of certainty, that if you grew, say, 10,000 apples from the pips produced by crossing two chosen types, you might get half a dozen of the desired type. In some cases the chances can be forecast with some degree of accuracy, but we cannot say what the quality or dimensions of any *single* individual in the progeny will be.

"The old hybridists could not know what the odds were against them or that some results they desired were impossible! They just crossed, planted their seedlings, dug them up and burnt them by the thousand. Occasionally they stumbled on a novelty that was a commercial success. Big battalions are still essential; it is not much good growing a thousand seedlings when the odds against the desired novelty are in the order of 10,000 to one.

"Even when you have produced a series of hybrids that settle some scientific problem, there is absolutely no guarantee that there will be one of market value. For instance, out of the 4000 new apples that Mr Crane has bred at John Innes, not more than forty have proved worth trying further for commercial purposes! But I think he has found an answer to one of the prayers of the apple farmer; apples which are immune against the attack of the woolly aphis. Derived from Northern Spy stock, these hybrids are being tested at the present moment in Canada, Australia, New Zealand, as well as in England."

Sir Daniel Hall's particular hobby has been the tulip; he hopes to conclude his official life with a review of the genus that will illustrate how the application of genetics and cytology clears up many of the problems of the classification of these plants.

WILLIAM E. DICK.

On the occasion of Sir Daniel Hall's 75th birthday, a collection of agricultural essays entitled *Agriculture in the Twentieth Century*, written by his personal friends, is being published by the Clarendon Press.

The essays include:

The Development of Agricultural Research. H. E. Dale.

Education and Extension Work. J. A. Hanley.

The Study of the Soil. Sir E. J. Russell.

Developments in Plant Breeding. H. Hunter.

Problems of Animal Nutrition. C. Crowther.

The Improvement of Grassland. Sir R. G. Stapledon.

The Propagation of Fruit Trees. R. G. Hatton.

The Economics of Farm Management. C. S. Orwin.

The Husbandman's Art. J. A. S. Watson.

The Evolution of Milk Production. J. Mackintosh.

Agriculture and the State. J. A. Venn.

The Fruits of the Marketing Acts. A. W. Ashby.

Agriculture and National Health. Sir John Orr.

Research in Virus Diseases. Redcliffe N. Salaman.

INVITATIONS TO KNOWLEDGE. IV

WHAT MAKES YOU A MAN

By

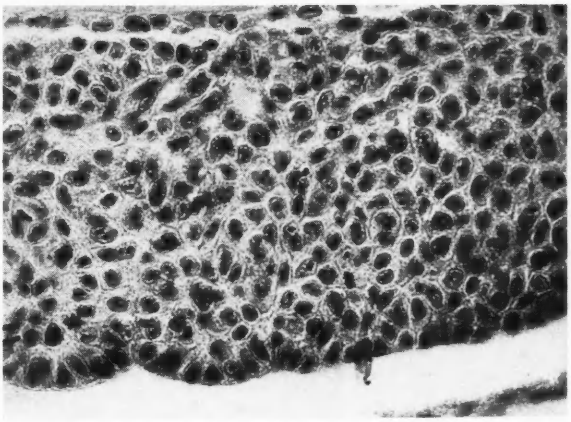
Dr C. H. Waddington

Have you ever wondered why you are human? Perhaps you will say it is because your father and mother were Mr Bunne the Baker and Mrs Bunne the Baker's wife, and not Spot the terrier or Tabby the cat. In a way you would be right. But your humanness is really part of *you*. You have got, I hope, a human face; your arms and legs are human; even your hair is different from the hair of any other animal, and if you are so unfortunate as to be hit over the head with a club, the detective who finds it will be able to tell, from the hairs sticking on to it, that it has been used to murder a man and not merely to beat a dog. What is it that makes every little bit of you a bit of a human being?

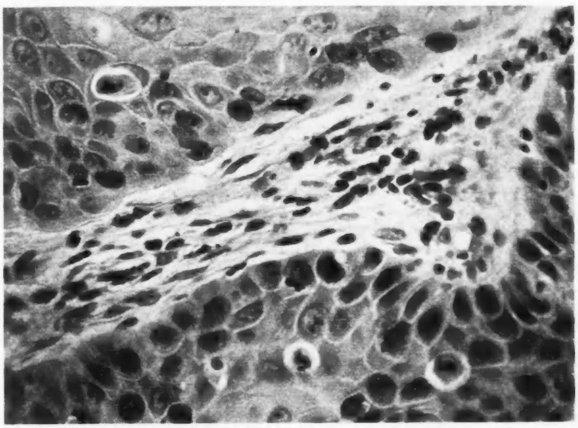
Every part of your body is built up of small lumps of jelly-like stuff; each lump is a *cell*. The only parts of you which do not consist of cells are things like your bones and hair and finger nails, which are non-living materials, and even they were originally made and put in place by cells. The cells are just too small to see with the naked eye, but if you were to scrape a little stuff from the inside of your lip and look at it with a magnifying glass, you would see some cells scattered about in the slime. These are the cells which line the surfaces of your body. There are the same kind of cells in your skin, but they lie a little way under the surface; the topmost cells of the skin are dead, and they gradually get worn away and replaced by new cells from below. In other parts of the body the cells look rather different. In muscles they are long and thin, like strings which pull on the bones and move them about. Nerves are made of other long stringy cells which carry messages about the body, rather as though they were telephone wires. And there are fat round cells in the liver which store up food-stuffs till they are needed, and in your lungs there are cells like jagged sheets of paper, through which oxygen from the air seeps through into the blood.

But in you all these kinds of cells are human. A dog has all the same kinds, skin and muscle and nerve and liver and so on, but in him they are dog cells. The difference between a dog cell and a man cell depends on the *nucleus*, which is a still smaller lump of jelly lying right in the middle of each cell. Inside the nucleus of each cell there is a set of minute rods and specks of jelly, which are known as *chromosomes*. And in each chromosome there are tiny particles known as *genes*; and it is these genes which make you a man or a dog.

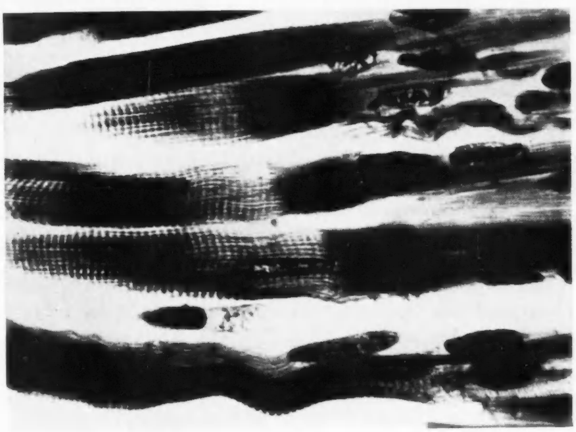
If the cells are so small that we have to look for them with a magnifying glass, the nucleus inside the cell is smaller still, so that it can only be seen with quite a good microscope. And the chromosomes are very minute indeed, about a thousandth of an inch long. But it is possible to stain them so that they show up well and to examine them with high-power microscopes. Then



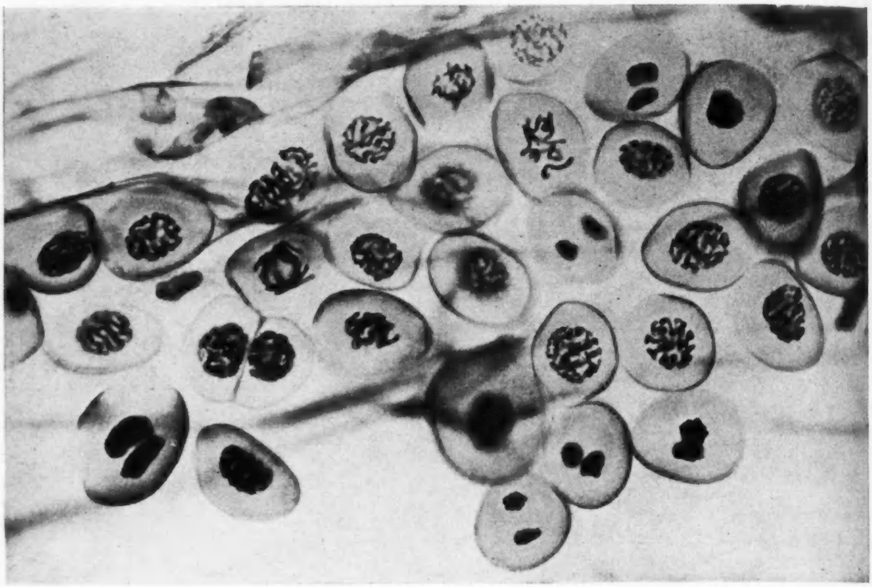
Cells from a young embryo. Part of the embryo has been killed and cut into a thin slice and then stained. With a microscope, you can see the cells, each one with a nucleus inside. The small dark spots inside the nuclei are not chromosomes, but bodies known as nucleoli. (*Magnification about* 500 *times*)



Cells from an adult man. There are two sorts of cell visible. The cell outlines can be seen best in the large flat cells at the sides. The nuclei are darker than the rest of the cell. (*Magnification* 500 *times*)



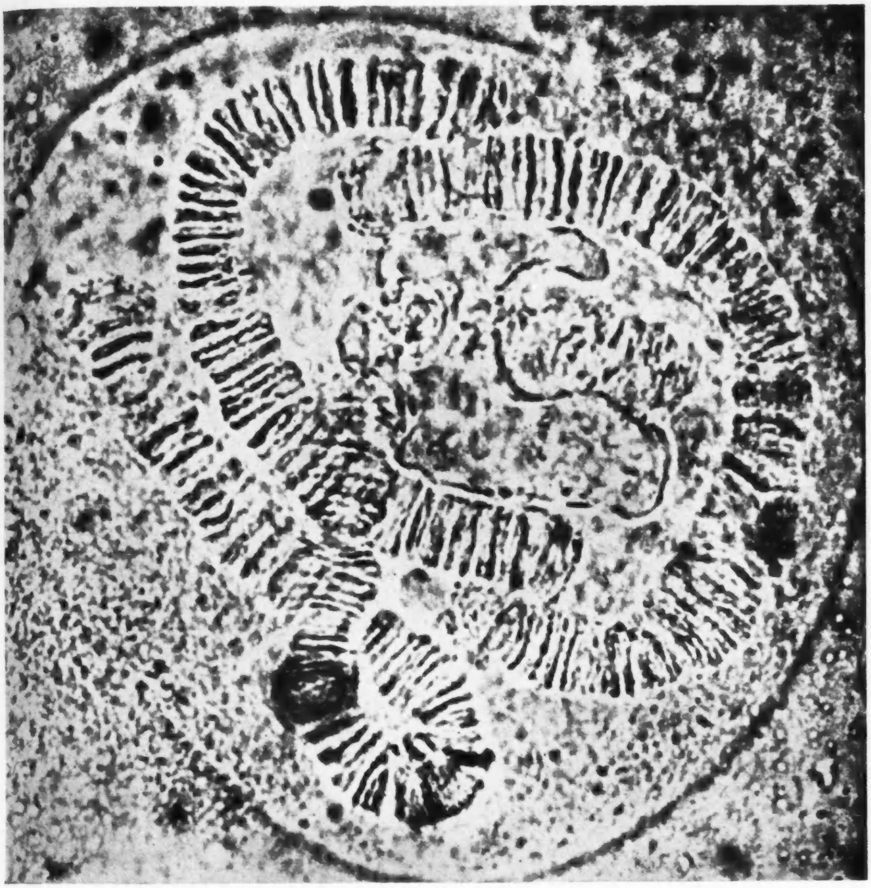
Muscle cells from a tadpole. The cells are very long, and have a fibrous appearance. The nuclei are the dark oval bodies.
(*Magnification* 400 *times*)



Pollen cells from a fritillary. The outlines of the nuclei are not visible, but in these cells the chromosomes can easily be seen. In some cells they are long and thin, and tangled up in a knot, while in other cells they are shorter, and look like little rods or V-shaped bodies

one can see that all the cells of a man, for instance, have the same kind of chromosomes, whether they are skin cells or muscle cells or liver cells, while all the cells of a dog, on the other hand, have a different number and kind of chromosomes. The genes inside the chromosomes are too small to be seen at all, but we are quite sure that the most important differences between human chromosomes and dog chromosomes are not the slight variations in size and shape which we can see if we examine them carefully, but are the different kinds of genes which they contain.

Chromosomes nearly always come in pairs. For instance, in a man each cell nucleus contains forty-eight chromosomes, and forty-six of these can be sorted in twenty-three different pairs; in each pair the two chromosomes are exactly alike, but each of the twenty-three pairs differs from the others in length, thickness and so on. But there are two chromosomes left over which do not fit into any of the pairs; one is a medium-sized rod-shaped chromosome, the other a very short one. Now the interesting thing is that we find these two only in the cells of a man. In a woman there are always two of the medium rod-like chromosomes, so that the whole forty-eight of her chromosomes make up an even twenty-four pairs. It is such an invariable rule to find twenty-four pairs in a woman, and twenty-three pairs and two unlike chromosomes in a man, that it seems likely that it is this difference in chromosomes which really causes the difference between men and women. Experiments with other animals, where the same sort of rules are found, has shown that this is really true. The twenty-three pairs of chromosomes, which are the same in men and women, have a tendency to make the cell male, while the medium rod-shaped chromosome we spoke of has a



The giant chromosomes in a cell of a fly. The cell was still alive when the photograph was taken, and the chromosomes have not been stained. The photograph shows only the nucleus and a very little of the cell. The curved striped bands are the chromosomes. (*Magnification about* 1500 *times*)

tendency to make it female. If a cell contains two of the rod chromosomes, they cause it to be a female cell, but if it has only one, the twenty-three other pairs are too strong for it and the cell is male. The little odd chromosome in the cells of a man has no effect; it is only a sort of dummy.

So that really it is not true that boys are altogether masculine and girls altogether feminine; they are both mixtures. If one likes, one could say that girls are just as much boys as boys are, because they both have the twenty-three pairs of masculine chromosomes; but boys are only half as much girls as girls are, because they have only one instead of two of the rod-shaped chromosomes. But of course this is true only of the chromosomes inside the cells; it is nonsense and does not mean anything if one says it about actual people.

Again, the really important things which make some chromosomes have a mas-

culinizing, and others a femininizing, effect are the genes which they contain. It is the kind of genes you have, too, which decides whether you have blue or brown eyes, or straight or curly hair, or whether it is quite easy for you to learn music or whether you have to practise more than most people to keep up with them. As the genes are so important, it is really very aggravating not to be able to see them. But even without seeing them, it has been possible to find out quite a lot about them.

In the first place, it was discovered that the genes in a chromosome are joined on to one another in a single row. This is just what one would expect, because, although the chromosomes usually look like thickish rods and lumps, they are really made of a very fine thread coiled up in a spiral, and this thread is so fine that there is no room for the genes to lie side by side; they have to lie in a row.

In some very special cells in flies, there are giant chromosomes, where the threads, instead of being coiled up, lie out straight. In these we can nearly see the genes. At least, there is a row of dark bands along the chromosome, and this must correspond in some way to the row of genes. But it is still unknown whether each band contains only one gene or whether there are several genes in some bands. The important thing is that by pure theory scientists had made a picture of a chromosome as a thing with genes in a row along it; and now these giant chromosomes, which have only recently been discovered, have shown that the picture was right; the chromosomes do have a row of things along them. If the chromosomes in a man were much bigger, or if our microscopes were much better, we might be able to look at your chromosomes and tell you whether you will grow bald early as you grow up, or whether you could be a good mathematician if you tried. Unfortunately, we cannot see chromosomes well enough to recognize different genes in them like this, and we probably never shall be able to. But the genes are there even if we cannot see them.

Reviews

Physics of Today

THIS book* will be of great use to teachers of physics in schools in providing a wide range of illustrations of the application of physics in the everyday life of the world. For example, in discussing Archimedes' Principle not only are all the ordinary illustrations given but the way a floating dock works is also explained. One illustration of machines is a picture of a long winding road in mountainous country, and it is pointed out that the ascent is long but easy. Illustrations of this sort cannot but prove useful to students, both as aids to memory and in impressing underlying principles on their minds. The book also contains numerous questions and tests which are so selected and framed as to test the student's knowledge of general principles and of the principles involved in particular applications. It provides the answer in a large number of connexions to the question "How does it work?"

Elementary physics can and should form an important part of a general education because a knowledge of its principles adds enormously to the appreciation of the significance of many everyday occurrences both natural and mechanical. If the methods used in this book were adopted as a model for teaching the subject in the lower classes in schools, it would certainly become more popular and more useful to the general student.

Anyone who has taken a School Certificate examination in physics will find little or no difficulty in reading the book and in gaining from it much useful information. It is to such readers and to teachers that it will mostly appeal, but it will also be useful to those who have some elementary knowledge of algebra and geometry and are willing to work through it systematically.

In the discussion on p. 124 of the forces acting on bodies in an air stream the well-known experiment on the distribution of

* *Physics of Today*, by J. A. Clark, F. R. Gorton and F. W. Sears. Constable, 8*s*. 6*d*.

pressure in a liquid moving in a tube of variable cross-section is not mentioned. In this particular experiment the physical explanation of the distribution is very simple and easily understood, and the inclusion of an account of it would have helped considerably to an understanding of the phenomena described. But it is obvious that there must be some omissions in a book of this scope, and the authors are to be congratulated on the interesting material they have collected. L. L.

The Birth and Development of Geological Sciences

THIS is a fascinating account* of the history of the science of geology from the earliest times, for the materials for which the author has searched diverse libraries, including those of the Vatican, the British Museum, the Congress in Washington, and the Geological Society of London. The field covered is very nearly complete, though the treatment is a little uneven, the emphasis being on the mining and mineralogical side. The arrangement, too, is perhaps a little confused; but it must be extraordinarily difficult to classify and arrange the results of such a wide historical survey. The chapters on "The Generation of Stones", on "Medieval Mineralogy" and "The Origin of Metals and their Ores", involve a certain amount of repetition; and it is something of a surprise to find the only references to William Smith, the Father of English geology, contained in the chapter headed "'Figured Stones' and the Birth of Palaeontology". Indeed, the subject-matter of this chapter on palaeontology is essentially stratigraphical, while the chapter on historical geology is concerned entirely with the Wernerian theory and its opponents.

The story opens with an account of the state of geology among the early Greeks, who accumulated, however, singularly little real knowledge; in fact, neither the Greeks nor the Romans contributed much beyond naïve speculation: "The aim and object of modern geological and palaeontological study was absolutely unknown to the ancients." Nor in the Middle Ages did the science fare any better against a background of mysticism and witchcraft. "With the sun of the new learning in the early Renaissance these mists and shadows began to fade away, but they were not wholly dissipated in Europe until it had risen high in the heavens and had shone for many long decades." However, with the development of mining in Saxony and Bohemia during the fifteenth century, minerals began to receive a more objective study. Agricola was the outstanding figure of that time, who broke away from the absurdities of medieval thought which endowed minerals and stones with all manner of magical and medicinal properties; he it was who laid the foundations of the early science of mineralogy, carried on in later centuries by Steno, Haüy and Berzelius.

The science of geology proper is of later growth, and although Leonardo da Vinci, writing in 1508, and others in the seventeenth and eighteenth centuries, had recognized the true nature of fossils, it was a long time before historical geology and palaeontology were placed on a scientific footing. There is a most interesting chapter on that brilliant if misguided teacher, Werner, and his Neptunian theory of the earth, and of the part played by Hutton and Playfair in discovering the true relations of stratified and igneous rocks. Hutton's greatness has never, perhaps, received quite the popular recognition accorded to that other British pioneer, William Smith. Of special interest in this chapter is the account of the conversion of Werner's pupil, von Buch, to "vulcanism", and the stress which the author lays on Hutton's recognition of the significance of unconformities. As another of our leading geologists has very recently said: the science of geology is essentially the study of rock contacts.

Considerations of space prevent any account of the many other interesting chapters, such as the Origin of Mountains, Earthquakes, the Origin of Rivers and Springs, etc. The book is to be recommended, however, not merely to geologists but to all interested in the history of science, as an extremely readable and entertaining volume; and it forms a useful work of reference to supplement Geikie's *Founders of Geology* and Zittel's *Geschichte der Geologie und Paläontologie*. O. M. B. BULMAN

* *The Birth and Development of the Geological Sciences*, by F. D. Adams. Baillière, Tindall and Cox, 22*s*. 6*d*.

British Waders

MR VESEY-FITZGERALD says in his Preface that this book* is in no sense a text-book, but a series of sketches; that is all to the good, for we now have many text-books. The author tells us what he has seen and heard himself, and in so doing gives the bird-watcher valuable hints on identification which are found in no text-book. In this he resembles the late Edmund Selous, whom he rightly calls "one of the greatest field naturalists of all time". (But for his over-elaborate literary style he would have received the recognition which is his due.)

* *A Book of British Waders*, by Brian Vesey-Fitzgerald. Collins, 7*s*. 6*d*.

Any field naturalist who has some acquaintance with waders knows how difficult it often is to be certain of their species. Many of them are wary—the prowling shore-gunner sees to that—and others so closely resemble each other that they are easily confused; add to this the evil eccentricities of our climate and the tricks which varying light and shade play with a bird's appearance, and it becomes obvious how welcome the personal experience of an expert is both to the tyro and to the case-hardened ornithologist.

Take, for instance, two birds as similar in appearance as the little stint and Temminck's stint. The latter is about a quarter of an inch smaller than the former, a difference "not very noticeable on the shore". But Mr Vesey-Fitzgerald tells you how to distinguish the two species by their call notes, and how Temminck's stint towers when it gets up, while the little stint does not. (Temminck's also has fewer striations on the back.) As to the godwits, he explains how you can separate the black-tailed from the bar-tailed not only by its long legs extending in flight beyond the tail but by its cry and other characteristics.

The wood and the green sandpiper may easily be confused, but he points out the difference in the upper tail coverts, so noticeable in flight, and in the under surface of the wings of the two species; these marks are more reliable than the coloration of the legs (those of the wood-sandpiper in my experience vary from light brown to greenish, according to the light). He relates how he nearly missed seeing an avocet among a flock of black-headed gulls, although he had before doubted the dictum of the bird books that it is easy to overlook them in that company. Other watchers may have inadvertently overlooked this rare bird in the same manner.

He does not accept the theory that the drumming of the snipe is produced by the two outer tail feathers. The usual experiments made with feathers stuck in a cork and whirled round, or affixed to an arrow, do not, to him, produce exactly the same sound. Other species of snipe, he says, drum, though they lack these tail feathers. And he adds that the great snipe drums on the ground and that a tame common snipe kept by a gamekeeper, drummed on the ground. If this record is authentic it certainly seems to throw doubt on the accepted theory. The same controversy arises over the drumming of greater and lesser spotted woodpeckers, though my own observations convince me that this is purely mechanical.

Mr Vesey-Fitzgerald has admirable descriptive powers. "Forlorn" of the curlew's cry is excellent: it is a lost spirit. He shows sympathetic feeling for landscape as a background for birds, a point often overlooked in bird books. He knows the charm of solitude on the shore.

He is no pedant: at times he writes with a delightful naïveté:

"I like finding a snipe's nest. It always gives me great pleasure. And I like hearing a snipe drum. I know no more pleasant sound at the dawning of a March day above a Hampshire marsh, or at dusk of a June evening in the still water-meadows."

He believes that when both sexes are alike in plumage, e.g. oyster-catchers, courtship is mutual. There is much to be said for this theory, but it needs working out by systematic observation before it can be regarded as definitely proved. He doubts whether the name "Seven-whistler" is in any way apposite for the whimbrel: he has never yet counted seven repetitions of the call: neither have I: three is most usual. And I can confirm his observation that in golden plover evolutions there is no permanent leader. I have watched them for many hours, and the leading bird certainly changes. Their invisibility when they settle on rocks by the seashore is extraordinary. They vanish as if by magic.

Egg collectors sometimes plead the depredations of the gamekeeper in extenuation of their own evil deeds, though why the damage done by one should excuse the further damage done by others I have never been able to understand. Mr Vesey-Fitzgerald rightly blames collectors for mopping up what was left of the breeding ruffs and black-tailed godwits, and adds that the precarious position of the Kentish plover is entirely due to the voracity of collectors. Dotterels have suffered from fly-fishers, who prize certain of their feathers. It is difficult in the face of these facts and of the precarious position of the kite in Wales to believe that the egg collector has not contributed seriously to the extermination in Britain of some species.

The book is remarkable for its excellent photographs. Those of the greenshank with two marsh-sandpipers, of the green and wood sandpipers are unique. But that of the common sandpiper showing its reflexion in the water, and of the grey and golden plover in breeding dress, have great beauty.

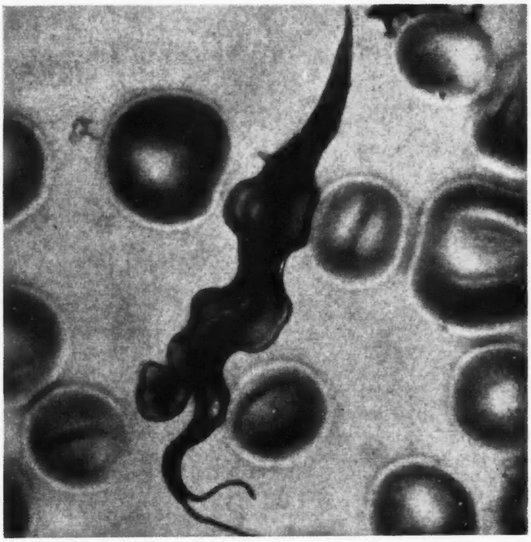
There is a very full appendix, giving descriptions and details of the distribution, nesting and food of the various species: its arrangement is admirable. The book is sanely and sympathetically written: it is a valuable contribution to British ornithology and will inevitably appeal to all bird-lovers who are content to watch.

E. W. HENDY

Brighter Invertebrates

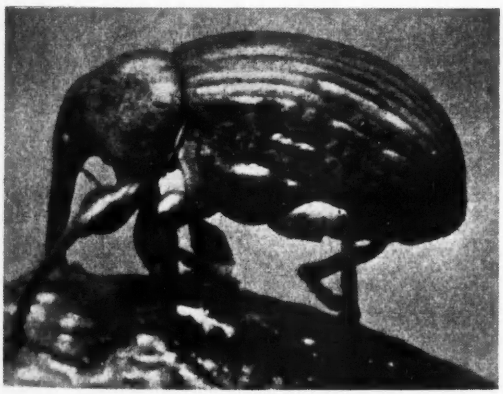
We are all familiar with those perfunctory chapters at the end of large volumes on Natural History, in which the author, having devoted 600 pages to the vertebrates and insects,

feels he can do justice in 50 pages to the remaining invertebrates. We are also familiar with the uncompromisingly text-book manner in which most serious introductions to invertebrate zoology are written. *Animals Without Backbones,** designed primarily for invertebrate zoology as a subject in a general university course, steers its way skilfully between this Scylla and Charybdis, and presents a treatment of its subject that is neither trivial nor forbidding. Its most striking feature is its wealth of illustrations; there are over 300 photographs, many of them taken from the living animal, and nearly all of quite remarkable quality, and nearly as many diagrams in a uniform style which, for its clarity and absence of irrelevant detail, deserves study by all future authors of text-books.



Trypanosome dividing in rat's blood. (*From* Animals Without Backbones)

The subject-matter is dealt with group by group in the usual order; the balance between the groups is, on the whole, well maintained (though the gastropods might with justice complain of very summary treatment), and the minor phyla are not neglected. This systematic treatment does not, however, preclude discussion of such general topics as amoeboid movement, bioluminescence, regeneration and biological gradients. There are also chapters on the palaeontology and phylogeny of the invertebrates. The style is simple and clear, and mercifully free from those *facetiae* to which American popular books are liable. The author is perhaps too frightened of Latin names, especially as there seems to be little consistency on this point; having swallowed the camel of *Diphyllobothrium*, why strain at the gnat of *Glossina*? Nor is it easy to believe that the timid beginner is much reassured by the use of "larvas" and "medusas" in place of the more usual plurals.



Cotton boll weevil at work. (*From* Animals Without Backbones)

In spite of the purpose for which it was written, the really valuable place for this book is in the school library, and no school should be without it. For a boy of sixteen or seventeen starting the study of biology it should be, like Chapman's *Homer*, or Chimborazo and Cotopaxi, the door to a new world of the imagination. If he gets no excitement and inspiration from this panorama of invertebrate life in all its weirdness and complexity he had better hastily take up some other subject.

There is one inaccuracy; the germ cells of sponges are derived from collar cells, and not, as stated, from mesenchyme cells; nor can it really be true that the increase in complexity of their canal system is a device to maintain the ratio of surface available for the location of collar cells to total volume. Otherwise, errors appear to be rare and for the most part unimportant.

D. A. W

* *Animals Without Backbones*, by Ralph Buchsbaum. Univ. Chicago Press, 25*s*.

Ultrasonics and their Scientific and Technical Applications

ULTRASONICS (sometimes called supersonics) are sound waves too short to affect the human ear; the shortest are of the order of magnitude of light-waves. But the laws of sound, valid for the audible range, hold also for the ultrasonic. In his book,* Dr Bergmann (Professor of Physics at Breslau University) describes a number of ways of generating these waves; some mechanical, i.e. by the use of small tuning-forks, or the Galton whistle, or gas currents. But the two means most used at present are: (1) magnetostriction—in this way, ultrasonics of frequencies up to 2000 K. Herz have been produced; and (2) the piezo-electric effect. By this latter method, quartz rods and plates are used as sound generators; the upper limit of the frequencies produced in this way is about 50,000 K. Hz. These vibrators are very thin and fragile; tourmaline plates (35 % thicker than quartz ones for the same natural frequency) are made now which give frequencies of 150,000 K. Hz. in the fundamental. To attain still higher frequencies overtones must be produced in plates of a lower natural frequency.

Instructions are given for setting up an ultrasonic equipment; and various methods are described of obtaining visible evidence of the longer of these waves—e.g. by means of *Lycopodium* powder, also by using dust (interference effects). An idea is given, by many photographs, of the beauty of these experiments. Other means are the use of air, or gas, in a tube containing some liquid; by this latter method highly accurate measurements of the wave-length of the sound in the gas may be obtained. The amplitude (or intensity) of ultrasonics can also be exactly gauged if, by various methods, the heat developed by them is measured.

By way of this heat, sound energy may be transformed into electrical energy.

There is a very interesting chapter on the diffraction of light by ultrasonics, which act as a grating. The last part of the book is concerned with the practical application of ultrasonics, such as: measurement of velocity of sound; exact measurements of wave-lengths of sound; in television; for submarine signalling; and for the testing of materials. The known biological effects of these waves are enumerated, and their possible uses in medicine, etc., are discussed.

M. B.

* *Ultrasonics and their Scientific and Technical Applications*, by Dr Ludwig Bergmann, translated by Stafford Hatfield. G. Bell and Sons, 16*s*.

Select List of Books Received by *Discovery*

(*Mention in this list does not preclude review*)

Modern Science. HYMAN LEVY. (Hamish Hamilton, 21*s*.)

The Growth of Science. A. P. ROSSITER. (Pitman, 5*s*.)

Science in Progress: The Society of the Sigma XI Lectureships. (Yale University Press, 18*s*.)

Practical Chemistry. JAMES BRUCE and HARRY HARPER. (Macmillan, 6*s*.)

May's Chemistry of Synthetic Drugs. (4th edition rewritten.) PERCY MAY and G. MALCOLM DYSON. (Longmans, 21*s*.)

Mellor's Modern Inorganic Chemistry. Revised and edited by G. D. PARKES and J. W. MELLOR. (Longmans, 12*s*. 6*d*.)

A Concise Organic Chemistry. N. F. NEWBURY. (Harrap, 3*s*. 6*d*.)

Elementary Survey of Physics. ARTHUR E. HAAS. (Constable, 7*s*. 6*d*.)

Theory and Practice of Electron Diffraction. G. P. THOMSON and W. COCHRANE. (Macmillan, 18*s*.)

School Experiments in Warfare Chemistry. W. KINTTOF. (Massie Publishing Co., 6*s*.)

Elementary Mechanics with Hydrostatics. D. HUMPHREY and E. A. BAGGOT. (Longmans, 8*s*.)

Aeroplanes and Aero Engines. P. H. SUMNER. (The Technical Press, 15*s*.)

A Systematic Regional Geography. Vol. 2. Europe. J. F. UNSTEAD. (University of London Press, 7*s*. 6*d*.)

Let's See If The World Is Round. HAKON MEILCHE. (Travel Book Club, 3*s*. 6*d*.)

Trailing Through Siberia. JOSEPH CRAD. (Travel Book Club, 3*s*. 6*d*.)

The Discovery of Man. STANLEY CASSON. (Hamish Hamilton, 12*s*. 6*d*.)

Men Who are Shaping the Future. EDGAR MIDDLETON. (Scientific Book Club, 2*s*. 6*d*.)

Vitalism. L. RICHMOND WHEELER. (Witherby, 15*s*.)

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